THAMES RIVER BASIN
NORWICH, CONNECTICUT

GREENVILLE DAM
CT. 00206

PHASE 1 INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

OCTOBER, 1980

UNCLASSIFIED

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Greenville Dam

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Greenville Dam is a long stone filled timber crib spillway structure with two earth embankments with vertical stone masonry facing forming the spillway abutments. The total length of the dam is 664 ft. including the 400 ft. timber crib spillway. The dam was judged to be in FAIR condition. The dam is classified as INTERMEDIATE in size and a HIGH hazard in accordance with the recommended guidelines established by the Corps of Engineers.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:

NEDED

MAR 0 6 1981

Honorable William A. O'Neill
Governor of the State of Connecticut
State Capitol
Hartford, Connecticut 06115

Dear Governor O'Neill:

Inclosed is a copy of the Greenville Dam (CT-00206) Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Protection, the cooperating agency for the State of Connecticut. In addition, a copy of the report has also been furnished the owner, City of Norwich, Norwich, CT 06360.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Protection for your cooperation in carrying out this program.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

GREENVILLE DAM

CT 00206

THAMES RIVER BASIN

NORWICH, CONNECTICUT

PHASE 1 INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE 1 INSPECTION REPORT

IDENTIFICATION NO:	CT 00206
NAME OF DAM:	Greenville Dam
COUNTY AND STATE:	New London County, Connecticut
STREAM:	Shetucket River
DATE OF INSPECTION:	7 April, 1980

Brief Assessment

The Greenville Dam is a long stone filled timber crib spillway structure with two earth embankments with vertical stone masonry facing forming the spillway abutments. The total length of the dam is 664 feet including the 400 feet timber crib spillway. The outlet works for the dam is a series of 6-10 ft. W x 10 ft. H gates leading to a downstream canal used for generating power at a downstream facility. This dam has a maximum height of 29.0 feet and was originally built in the year 1882.

The dam was judged to be in FAIR condition. However, because the river stage at the time of the visual inspection was high, the assessment of the dam is based only on those visible portions that could be readily inspected. Those components were the abutment embankments and the outlet structure. The spillway could not be evaluated. Several items require attention to insure the long term performance of the dam. They include: seepage at the left embankment, erosion at the toe of the left embankment, brush growth of the upstream face of the right embankment. Construction work at the left embankment has resulted in the temporary creation of a low area in that embankment crest.

The dam is classified as INTERMEDIATE in size and a HIGH hazard in accordance with the recommended guidelines established by the Corps of Engineers. The routed Test Flood outflow for this dam is equal to the Probable Maximum Flood (PMF) or approximately 140,000 CFS and would overtop the dam by 6.2 feet. The maximum spillway discharge of 84,480 CFS represents 60 percent of the test flood outflow. Because there are several flood control reservoirs located within the drainage basin of the dam that are owned and operated by the U.S. Army Corps of Engineers, it is very likely that a detailed analysis will indicate that the approximate inflow of 141,500 CFS and the overtopping potential used in this report will need to be modified to include their impact.

It is recommended that the Owner engage the services of a registered engineer experienced in the design of dams to accomplish the following:

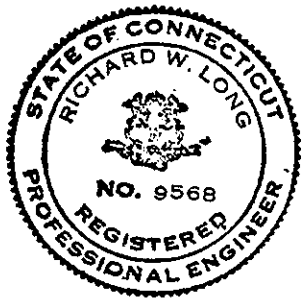
perform more detailed hydraulic and hydrologic studies to determine the discharge capacity and the overtopping potential of this dam taking into account the impact of upstream flood control structures in attenuating the flood, remove the vegetation from the right embankment, repair the road cut in the left embankment, and monitor the wet zones at the left embankment area.

Additional recommendations and remedial measures are detailed in Section 7 and should be implemented by the Owner within one year after receipt of this Phase 1 Inspection Report.

CE Maguire, Inc.

By: Richard W. Long

Richard W. Long, P.E.
Vice President



This Phase I Inspection Report on Greenville Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

RICHARD DIBUONO, CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase 1 Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, DC 20314. The purpose of a Phase 1 Investigation is to identify expeditiously those dams which may pose hazards to human life or to property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain condition which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase 1 inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonable possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition, and the downstream damage potential.

The Phase 1 Investigation does <u>not</u> include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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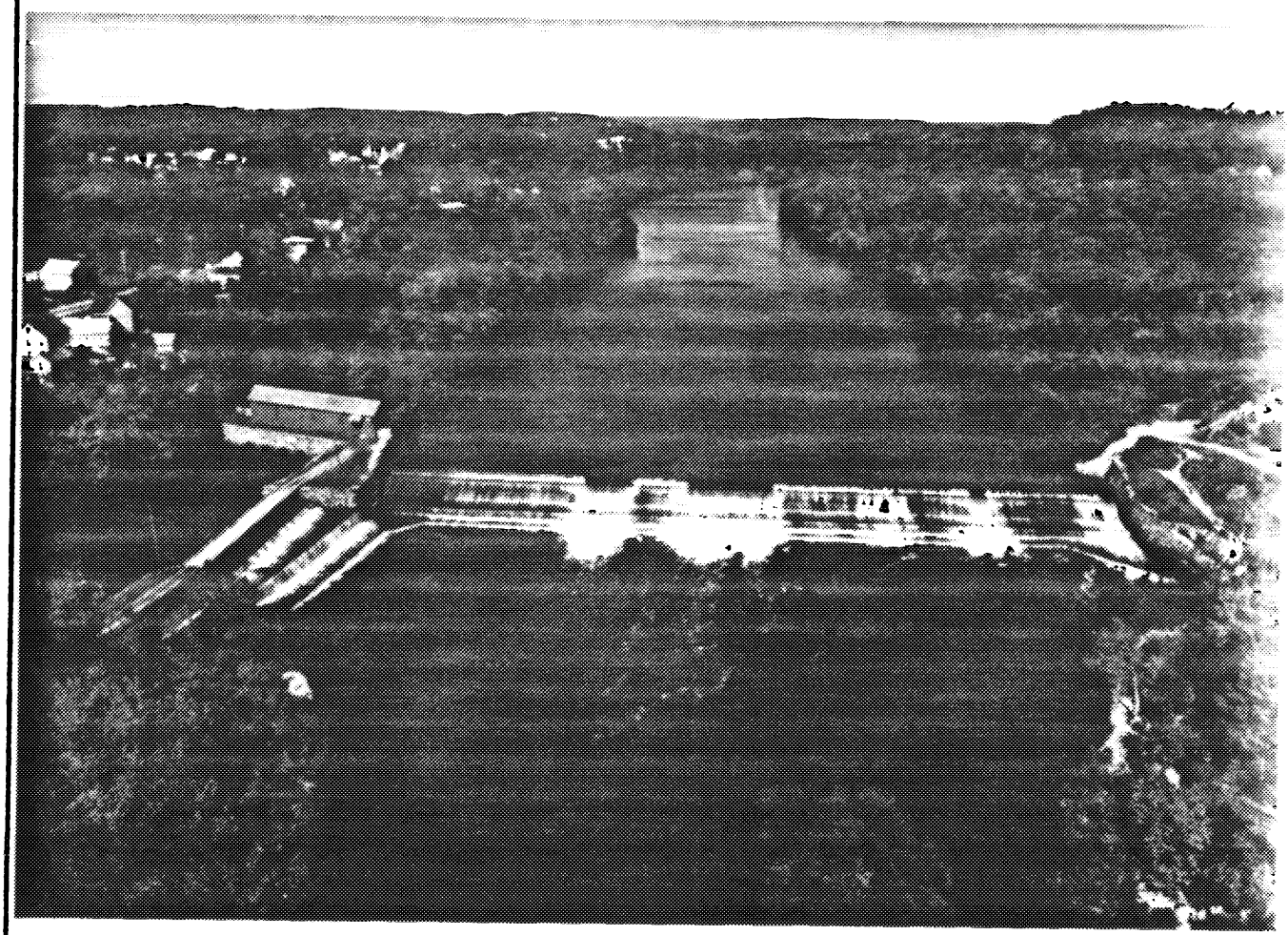
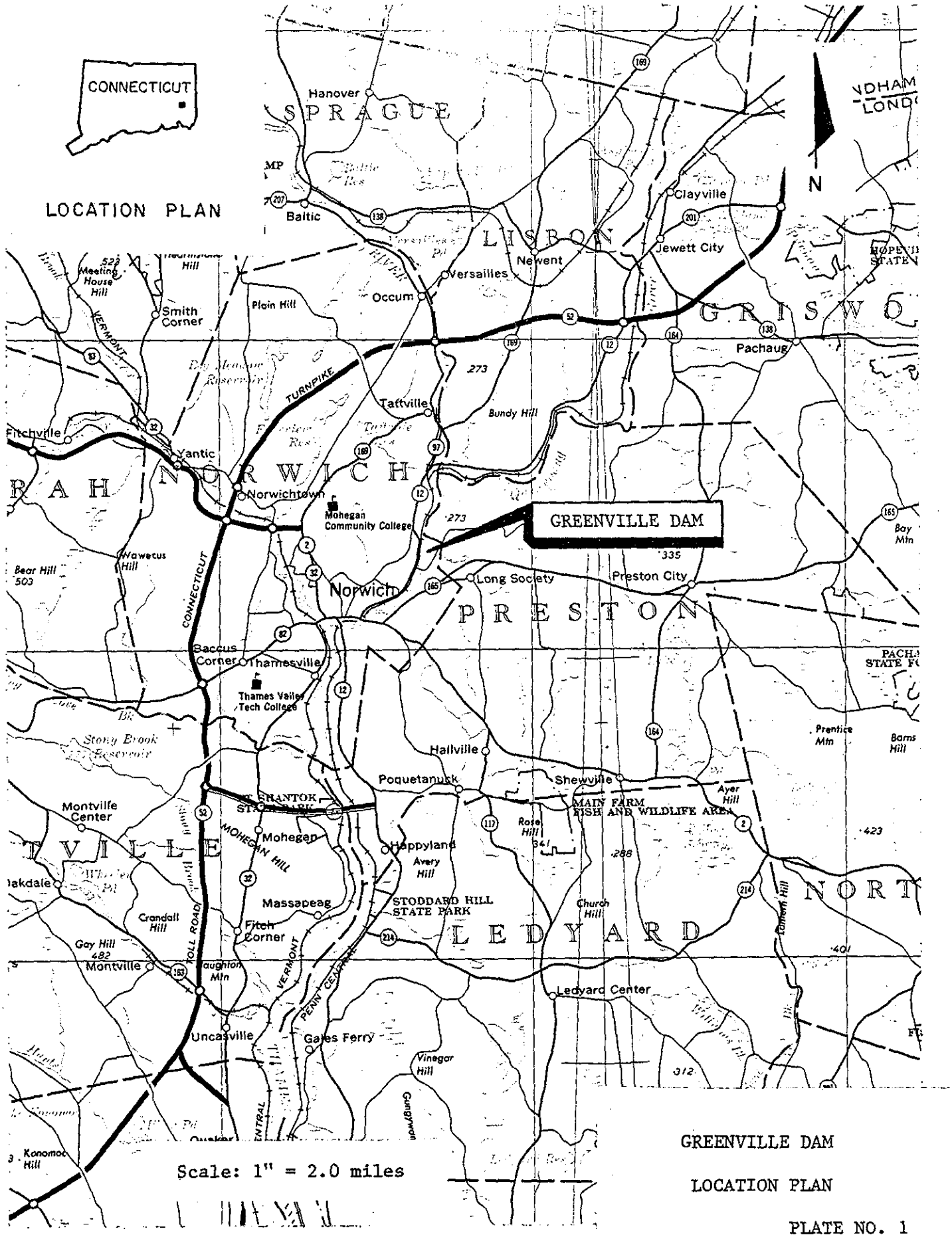


OVERVIEW PHOTO - Greenville Dam



GREENVILLE DAM

LOCATION PLAN

PLATE NO. 1

NATIONAL DAM INSPECTION PROGRAM

PHASE 1 - INSPECTION REPORT

GREENVILLE DAM

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army through the Corps of Engineers to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. CE Maguire, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Connecticut. Authorization and notice to proceed was issued to CE Maguire, Inc., under a letter from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW33-80-C-0013 has been assigned by the Corps of Engineers for this work.

b. Purpose of Inspection.

1. Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

2. Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

3. To update, verify and complete the National Inventory of Dams.

1.2 Description of the Project

a. Location. Greenville Dam is located in the city of Norwich, New London County, Connecticut. Coordinates of the dam are approximately 41° 32.3' N Latitude and 72° 03.1' W Longitude. The dam impounds water in the Shetucket River which drains 1,261 square miles of rolling terrain. The dam is located about 11,000 feet upstream from the confluence of Shetucket River and the Thames River. The axis of the dam is oriented in a east-west alignment with the river impoundment to the north of the dam.

b. Description of the Dam and Appurtenances. The Greenville Dam is a stone filled timber crib spillway structure with stone faced earth embankments at each abutment. The total length of the dam is 664 feet. Earth embankments at each end of the spillway structure comprise 264 feet of the total length. The spillway length of 400 feet extends the entire width of the Shetucket River. The left embankment has a top width of 42 feet and the top width of the right embankment is 26 feet. The right embankment also contains the outlet works for the dam. The outlet works is a stone masonry structure with 6 arch openings of 10 foot width and 10 foot height on the downstream face and rectangular openings of the same size on the upstream face. The control gates for these openings are constructed of timber and are in two panels, similar to a double hung window. They operate by sliding vertically and are raised by rack and pinion equipment. Three of the gates have been fitted with electrical hoist mechanisms. A timber gatehouse encloses the operating facilities. (See Photo C-10 in Appendix C). Gates are in operable condition.

The spillway is a timber crib work with stone-fill. See the drawings in Appendix B-3 for details. The length of the spillway weir is 400 feet and the width at the crest is 7 feet. The dam has a provision for installation of 1.3 feet high flashboards along the spillway crest. This could not be verified during the visual inspection due to the large overflow at the time. Discharge from the spillway continues in the Shetucket River. The discharges from the outlet works flow into a downstream canal which parallels the Shetucket River. The water surface in the outlet canal was about 12 feet above the river stage at the time of the inspection. The water in the outlet canal is utilized for hydroelectric power generation at a facility further downstream. This outlet canal has a side channel spillway as shown on a sketch in Appendix C and Photo C-12 to limit the maximum discharge entering the powerhouse.

c. Size Classification. The Greenville Dam has an impoundment capacity at the top of the dam (elev. 36.3 feet NGVD) equal to 3360 Ac-Ft and a maximum height of 29 feet. In accordance with guidelines established by the Corps of Engineers, this dam is classified as an INTERMEDIATE size structure based on its impoundment capacity.

d. Hazard Classification. This dam is classified as a HIGH hazard potential structure because its failure could result in loss of more than a few lives, damage and inundation of 20-25 dwellings and commercial properties in the City of Norwich, damage to the support structures for the 8th Street, Main St. (Rt. 2), Rt. 12, Water Street and Amtrack Railroad bridges and temporary disruption to traffic and utility services located within or along those roadways. Loss of the dam will also prevent the generation of electricity by the City of Norwich.

It is estimated that the failure discharge of 131,720 CFS will travel downstream through the Shetucket River with high velocities. Depths of flow downstream from the dam before and after the dam failure are 18.0 and 21.0 feet for respective discharges of 84,480 and 131,720 CFS. Increased depth in the inspected areas due to failure of the dam will be approximately 3.0 feet and there will be 4-7 feet of water in the impacted dwellings and commercial properties. The failure will cause flooding conditions downstream and the velocity of flow will carry debris and cause erosion.

e. Ownership. The dam is presently owned by the City of Norwich, Connecticut.

f. Operator. The dam is operated by the City of Norwich, Department of Public utilities, 34 Shetucket Street, Norwich, Connecticut, 06360. Personnel are under the direction of Mr. C.F. Rossoll, Chief Electrical Engineer (1-203-887-2555).

g. Purpose of Dam. To provide water for hydroelectric power-generation for the Department of Public Utilities, City of Norwich, Connecticut.

h. Design and Construction History. The Greenville Dam was built in 1882. Records indicate that replacement of the timber planking started about 1947. Damage occured to the planking during the intense storms of 1955 and additional repair work was apparently performed. Other recorded repair work has been performed in 1965, 1969, 1978 and at the present time, April 1980. Records indicate that all of the foregoing repairs were to the timber spillway only.

i. Normal Operational Procedure. The outlet gates are adjusted to maintain water level in the outlet canal to avoid spillover in the side channel spillway located on this canal. Normally, the water level can be maintained by leaving the gates wide open. When the river level is high, the gates are partially closed to cut back the flow. Chart recorders register the water level in the river upstream of the spillway crest and in the outlet channel. A daily record of the level is maintained. Spillover in the canal side channel spillway structure is reduced somewhat by leakage to the river by canal water along the length of the channel. This intake canal, 2500 feet long, leads to a hydroelectric generation facility with 2200 KW installed capacity and an average net-head of 14.0 feet. The plant is shut off during the high floods when sufficient differential head (difference between upstream and tailwater elevation) is not available and this is done by closing the upstream gates.

1.3 Pertinent Data

a. Drainage Area. The drainage basin for the Greenville Dam is approximately 60 miles long, 30 miles wide and equal to 1,261 square miles in area. The basin extends from the Spencer State Forest near Worcester, Massachusetts in the north, to Norwich in the South; and from the Connecticut-Rhode Island State Line in the east to Manchester in the West. The topography is generally flat to rolling terrain with elevations ranging from a high of 1,074 feet at Spencer State Forest to 20.3 feet at the spillway crest. In addition, the large storage areas and flood control structures within the watershed will tend to dampen and delay the peak of the surface runoff. There are six flood control structures located upstream within the watershed with the following pertinent features:

Reservoir	Controlling D.A.	Remarks
Mansfield Hollow	159.0	For Greater
Buffumville	26.5	Details See
Hodge Village	31.0	Appendix F
East Brimfield	67.5	
Westville	32.0	
West-Thompson	74.0	

b. Discharge at the Damsite. Recorded levels of the Shetucket River are continuously obtained at the damsite by the City of Norwich. There is no other discharge data available for this dam. Listed below is calculated discharge data for the spillway and outlet works:

1. Outlet Works:

Conduit size	6-10' x 10' rectangular Conduit invert elevation 9.30 feet (Total area = 600 square feet)
i. Discharge capacity	7,350 CFS @ spillway crest elevation 20.3
ii. Discharge capacity	14,070 CFS @ top of dam elevation 36.3 feet
iii. Discharge capacity	14,650 CFS @ test flood elevation 38.15 feet
2. Maximum known flood at damsite	September, 1938 - 75,000 CFS

3.	Ungated spillway capacity at top of dam	84,480 CFS
4.	Ungated spillway capacity at test flood elevation	140,000 CFS
5.	Gated spillway capacity at normal pool elevation	N/A
6.	Gate spillway capacity at test flood elevation	N/A
7.	Total spillway capacity at test flood elevation	140,000 CFS
8.	Total Project discharge at top of dam	98,550 CFS
9.	Total Project discharge at test flood elevation	154,650 CFS

c. Elevation (Feet NGVD)

1.	Streambed	7.3
2.	Bottom of Cut-off	Unknown
3.	Maximum tailwater	Unknown
4.	Recreation Pool	N/A
5.	Full flood control pool	N/A
6.	Spillway crest	20.3*
7.	Design discharge (orginial design)	Unknown
8.	Top of dam	36.30
9.	Test Flood design surcharge	42.50

d. Reservoir (Length in feet)

1.	Normal pool	6,000 (estimated)
2.	Flood control pool	N/A
3.	Spillway crest pool	6,000 (estimated)
4.	Top of dam	6,000 (estimated)

*Spillway crest - elevation adopted in Master Manual of Reservoir - Thames River Basin = 21.40.

5.	Test flood pool	6,000 (estimated)
e.	Storage (acre-feet)	
1.	Normal pool	800
2.	Flood control pool	N/A
3.	Spillway crest pool	800
4.	Top of dam	3,360
5.	Test flood pool	4,200
f.	Reservoir Surface (acres)	
1.	Normal pool	160
2.	Flood control pool	N/A
3.	Spillway crest pool	160
4.	Top of dam	160
5.	Test flood pool	160
g.	Dam	
1.	Type	Wooden crib stone filled dam.
2.	Length	664 feet
3.	Height	29 feet
4.	Top width	Varies
5.	Side slopes	Varies
6.	Zoning	N/A
7.	Impervious Core	Unknown, crest wooden crib stone & earth filled
8.	Cutoff	Unknown
9.	Grout curtain	Unknown
10.	Other	---

h.	Diversion Channel	Intake flume to the powerhouse for hydro-generation.
	1. Type	Rectangular channel
	2. Length	2,500 feet
	3. U/S Control	6 - 10' x 10' gates with invert 9.3 elevation
	4. Gates	Yes
	5. There is a side channel spillway on this intake canal (see Photo C-12) Refer to paragraph 1.1i for more details.	
i.	Spillway (at dam)	
	1. Type	Uncontrolled overflow (granite cap) weir, cascade downstream face.
	2. Length of Weir	400 feet
	3. Crest elevation with no flashboards	20.3 feet
	Crest elevation with flashboards (no flashboards were observed at time of inspection)	21.3 feet
	4. Gates	None
	5. U/S Channel	Natural river bed Shetucket River
	6. D/S Channel	Natural river bed Shetucket River
j.	Regulating Outlets	
	Refer to paragraph 1.2b "Description of Dam and Appurtenances" for description of outlet works.	
	1. Invert	9.3 feet

2.	Size	6 - 10 feet x 10 feet
3.	Description	6-slide type wooden gates-stone masonry structure
4.	Control Mechanism	3 electrically assisted or manually operated wooden gates plus 3 manually operated gates.
5.	Other	---

SECTION 2

ENGINEERING DATA

2.1 Design Data

The following documents which contain the principal information regarding this dam were reviewed in the preparation of this report.

1. Plans entitled: "Norwich Water Power Company's Dam". Three (3) sheets prepared by Chandler and Palmer, Engineers of Norwich, Connecticut, dated December 1915.

2.2 Construction Data

Correspondence relating to repair work dating from 1947 was available for review.

2.3 Operation Data

Water levels are recorded and maintained by the City of Norwich Department of Public Utilities.

2.4 Evaluation of Data

a. Availability. The information noted above for this facility is available in the files of the:

State of Connecticut
Department of Environmental Protection
State Office Building
165 Capitol Avenue
Hartford, Connecticut
Attn: Mr. Victor J. Galgowski,
Dam Safety Engineer

and

City of Norwich,
Department of Public Utilities,
34 Shetucket Street
Norwich, Connecticut 06360
Attn: Mr. C.F. Rossoll
Chief Electrical Engineer

b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assured from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance and sound engineering judgement.

c. Validity. The validity of the limited data must be verified.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. The Phase 1 inspection of Greenville Dam was performed on 17 April, 1980 by representatives of CE Maguire, Inc., and Geotechnical Engineers, Inc. A visual checklist and photographic record of that inspection has been included in Appendix A and C, respectively, of this report. At the time of the inspection approximately 1.5 feet of water was flowing over the crest of the spillway. Since this flow entirely covered the spillway structure making it unobservable, the condition of the spillway has not been rated. The overall rating of embankments and appurtenant structures is judged to be FAIR. This evaluation is based on the visual inspection, history, existing drawings and general appearance.

b. Dam.

1. Spillway. Existing drawings, of the dam, indicates the main spillway section of the dam is constructed of timber cribbing filled with hand packed stones. The spillway is approximately 400 ft-long. Currently, repair work is taking place at the dam site as shown on Photo C-3. Several of the sheet piles can be seen protruding from the water surface. The repair to the spillway is reportedly replacement of deteriorated timbers of the crib and surface timbers and backfilling along the upstream face with gravel.

2. Left Embankment. The left masonry block wall of the dam is shown in Photos C-1 and C-5. A concrete training wall has been built downstream from the masonry wall to divert water away from the toe of the downstream masonry wall and adjacent earth embankment (Photos C-5 and C-7). A roadway has been excavated adjacent to the left abutment as indicated in Photos C-1 and C-4. This roadway construction has created a minor depression in the crest profile of the dam. The length and depth of this depression could not be measured and inspected due to overflow conditions. A small seep was noted near the downstream toe of the embankment approximately 30 ft. to the left of the end of the masonry training wall. This seepage zone can be observed in Photo C-13. The Owner reports that repair work is presently taking place at the toe of the left embankment where a small tributary flows into the

Shetucket River just downstream from the spillway (See Photo C-14). This repair includes the installation of a pipe and headwall to carry the tributary flows more readily into the main river.

c. Appurtenant Structures and Right Embankment.

1. Outlet Works and Right Embankment. The outlet works and right embankment form a continuous structure at the right end of the spillway. This complex is shown in the overview photo. The downstream side end of the outlet works structure is shown in Photo C-10 and the intake side in Photo C-2. The stone masonry forming this structure appeared to be in fair condition with missing mortar in many areas and trees and vines growing out of the base of the wall. The right abutment of this structure is shown in Photo C-6.

2. Gatehouse and Gate Controls. The gatehouse is a timber superstructure on the stone masonry portion of the embankment. This structure is shown in Photos C-2, C-10, and C-12. The general condition of the superstructure was to be judged fair. The gates appeared to be well maintained and in operating condition although an operational check was not conducted. Three of the six gates can be electrically operated, the remaining gates are manually operated.

3. Canal Outlet Channel Spillway. This structure is shown in Photo C-12. The structure is of concrete and judged to be good condition.

4. Canal Intake Channel. The intake channel is shown in Photo C-9. The channel runs parallel to the Shetucket River and is connected with the river immediately upstream from the gatehouse (Photo C-2). The location of the intake channel is visible in the overview photo as a break in the trees upstream from the gatehouse. There are many overhanging trees and branches.

5. Canal Outlet Channel. The outlet channel which feeds the various users of water downstream from the dam is shown in Photo C-11. The outlet channel spillway is shown in Photo C-11 on the left hand side. Masonry walls form the left side of the channel while natural earth embankment forms the right side. The sidewalls of the canal appear to be in good horizontal and vertical alignment above the water line at the time of the inspection with no apparent sloughing. The length of this channel is 2500 feet.

d. Reservoir Area. No specific detrimental features were observed in the reservoir during the visual inspection. The slopes of the shoreline are overgrown with trees and brush. Because of the dense vegetation, periodic observations should be made to check for debris such as tree trunks and limbs which could become entrapped on the spillway crest or outlet gates.

e. Downstream Channel. The downstream channel is the natural riverbed of the Shetucket River. No significant obstructions existed in the channel at the time of inspection (See Photo C-8).

3.2 Evaluation

A thorough Phase 1 evaluation of the spillway portion of the dam could not be performed because water flow over the crest prevented access to the downstream portion of the dam.

Based on examination of the embankments and appurtenant structures, these observable features were judged to be in fair condition. The following deficiencies could adversely affect the future performance of the dam:

1. Seepage exiting at the downstream toe of the embankment section at the left side of the dam could affect the long-term integrity.

2. The road which has been cut into the left abutment may lead to future erosion and a possible breach of the embankment during periods of high runoff.

3. Trees and vines existing at the toe of the upstream face of the outlet works structure could lead to displacement of the masonry block if allowed to continue to grow.

4. An inspection and evaluation of the spillway should be made during a low flow period.

5. The minor depression on the spillway crest noted at the left embankment does not significantly increase the volume of overtopping but should be corrected under normal maintenance.

SECTION 4

OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. The Greenville Dam is regulated by the personnel of the City of Norwich, located at Department of Public Utilities City of Norwich, South Golden Street.

The gates are normally maintained in the open position. During high flows, the gate openings are adjusted to avoid water spilling over the side channel spillway due to reported seepage and stability problems on this structure. During flood flows, the gates are completely closed and the power plant shut-off because the reduced head on the turbine units is too small for their efficient operation. Daily records are maintained of water level in the outlet canal and river above the dam.

b. Description of Any Warning System in Effect. Emergency procedures are posted at the power station which is located on the outlet canal several hundred feet downstream from the dam. A copy of these procedures is included in Appendix B-1.

4.2 Maintenance Procedures

a. General. Trees and brush growing on the embankments are generally trimmed side cut on an annual basis. Maintenance was in progress on a portion of the spillway as can be seen in the Photo C-3. Except for some vegetation growing from the masonry of the embankment the facilities appeared to be well maintained.

b. Operating Facilities. All of the gates receive as needed maintenance to keep them operable. At the time of the inspection, 3 of the gates had recently been overhauled. One gate had been replaced in its entirety, two others, partially replaced.

4.3 Evaluation

It is not possible to comment on the effectiveness of maintenance of the timber crib spillway at this time. The outlet gates, right embankment and outlet channel spillway appeared to be well maintained. These facilities are observed by City of Norwich operating personnel on a daily basis. The left embankment area is maintained to the extent of cutting brush and trees. Erosion areas require further maintenance.

SECTION 5

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General. The Greenville Dam is located on the Shetucket River, in eastern Connecticut, approximately 2.1 miles northeast of the confluence of the Thames and Shetucket Rivers. The dam was constructed around 1882 and is presently used to produce electrical power by means of a low head hydro facility located downstream. At the spillway crest elevation of 20.3 feet, the capacity of the outlet structure is 7,348 CFS. It would require one-half hour to lower the reservoir level one foot. To drain the 800 Ac-Ft of available storage below the spillway crest, it will require 3 hours using the existing outlet.

The dam has a spillway length of 400 feet and a surcharge height of 16 feet. The total length of the dam is 664 feet. The reservoir has a storage capacity at the spillway crest level of 800 Ac-Ft and can accommodate .012 inches of runoff from the watershed. Each foot of depth in the reservoir above the spillway level can accommodate 160 Ac-Ft of water equivalent to 0.002 inches of runoff.

At the spillway crest elevation of 20.3 feet the capacity of the outlet structure is 7,348 CFS. It would require one-half hour to lower the reservoir level one foot. To drain the 800 Ac-Ft of available storage below the spillway crest, it will require 3 hours using the existing outlet.

5.2 Design Data. Limited design data is available for this watershed and dam. To supplement the existing design information U.S.G.S. Topographic Maps (scale 1" = 2,000 ft.) were utilized to develop hydrologic parameters such as drainage area, reservoir surface areas, basin slopes, time of concentration and other runoff characteristics. Elevation/storage relationships for the reservoir were estimated. Surcharge storage was computed assuming the surface area remained constant above the spillway crest. Some of the pertinent hydraulic data was obtained and/or confirmed by actual field measurements at the time of the visual inspection. Test flood values and dam failure profiles were developed in accordance with the Corps of Engineers guidelines. Final values used in this report are quite approximate and are no substitute for detailed analysis.

5.3 Experience Data. Historical data for recorded discharges and water surface levels as available for this dam are reproduced below:

Date	Discharge in CFS	Stage
1936, March	51,500 (37,200)*	32.0 (30.4)*
1938, September	75,000 (47,200)*	35.0 (32.0)*
1955, August	65,000 (35,200)*	35.0 (30.0)*
Standard Project Flood	129,000 (94,000)*	42.0 (38.2)*

*Modified by upstream reservoirs in the watershed.

5.4 Test Flood Analysis. Recommended guidelines for the Safety Inspection of Dams by the Corps of Engineers were used for selection of the "Test Flood". This dam is classified under those guidelines as a HIGH hazard and INTERMEDIATE in size. Guidelines indicate that the full PMF be used as the test flood for such classification. The watershed has a total drainage area of 1,261 square miles of which (10%) is swampy or covered by natural storages. This drainage area is sparsely populated, largely wooded, is hilly with rolling terrain, with basin slopes averaging 0.004 feet per feet which can be considered as flat. A "test flood" equal to the full PMF was calculated to be 112 CSM, equal to 141,500 CFS and was adopted for this analysis. The routed outflow discharge for the test flood inflow was 140,000 CFS assuming the outlets to the hydro-generating intake canal are closed. The discharge through these outlets to the hydro-generating facilities is 14,650 CFS at the Test Flood elevation thus making total project discharge at the Test Flood elevation 154,650 CFS. Total project discharge at top of dam is 98,550 CFS with 14,070 CFS passing the intake canal outlet structure. The spillway and outlet rating curves are illustrated in Appendix D. Flood routings were performed assuming a full reservoir (at spillway crest elevation.)

In the Master Manual for Reservoir Regulation - Thames River Basin by the Corps of Engineers a Standard Project Flood of 96,000 CFS for local protection works in Norwich was developed for the Shetucket River with the storm centered over the uncontrolled drainage area downstream of the six flood control Corps of Engineers structures (Willimantic River Basin). The Test Flood (full P.M.F.) adopted for this Phase 1 Inspection Report is 141,500 CFS approximately 47% larger than the SPF and is assumed to be centered on the entire the 1261 sq. mile basin.

Test Flood should be redone including the impact of flood attentuation of the six Corps of Engineers reservoirs located upstream as detailed in Appendix F for a more detailed and realistic analysis.

The analysis indicates that the spillway capacity is not hydraulically adequate to pass the selected "test flood" (full PMF) for this dam and this flow would overtop the dam by approximately 6.2 feet. Overtopping of this dam has been computed assuming a uniform dam crest because the low point on the roadway at the left embankment is considered a temporary construction condition. The inflow and routed outflow discharge value for this test flood are 141,500 CFS and 140,000 CFS, respectively. The maximum outflow capacity of the spillway without overtopping the dam is 84,480 CFS which is 60.3 of the routed test flood outflow. Because of large flood control storage located upstream, a detailed analysis to determine the inflow at this dam is required to obtain a realistic magnitude and outflow and the overtopping potential.

5.5 Dam Failure Analysis. An instantaneous full depth-partial width breach of 200 feet was assumed to have occurred in the dam. This adopted breach width of 200 feet was based on visual inspect[illegible] of

the downstream channel and topographic features. Assuming the river stage at the top of the dam just prior to failure the calculated dam failure discharge is equal to 131,720 CFS with outlet gates assumed closed.

This discharge will produce an approximate water surface level of elevation 28.3 feet immediately below the dam and will raise the water surface 3.0 feet above the level just prior to failure when the discharge is equal to 84,480 CFS. The reach of the river that will be impacted by this dam failure is that portion extending from the dam downstream to the Thames River. The failure discharge of 131,720 CFS may result in loss of more than a few lives, inundation of 20-25 dwellings and commercial properties in the City of Norwich, damage to the support structures for the 8th Street, Main St. (Rt. 2), Rt. 12, Water St. and Amtrack Railroad bridges and temporary disruption to traffic and utility services located within or along those roadways. Estimated depths of water from the dam failure discharge at those structures impacted by the failure could range from 1-3 feet. Riverbanks will sustain severe erosion and stripping and that the debris carried along by the failure wave can result in additional damage and flooding. Depths of flows downstream of the dam before and after failure are 18.0 and 21.0 feet for respective discharges of 84,480 and 131,720 CFS. In the vicinity of 11,000 feet downstream from this dam backwater effects from the Yantic and Thames River Basin will also affect the water surface elevations during high floods. As a result, the Greenville Dam has been classified as INTERMEDIATE in size but HIGH hazard structure.

GREENVILLE DAM

Inflow, Outflow and Surcharge Data

FLOOD	24-HOUR TOTAL RAINFALL IN INCHES	24-HOUR* RUNOFF IN INCHES	MAXIMUM INFLOW IN CFS	MAXIMUM** OUTFLOW IN CFS	SURCHARGE HEIGHT IN FEET	SURCHARGE STORAGE ELEVATION
TEST FLOOD	21.4	19.0	141,500	140,000	22.20	42.5

*Infiltration assumed as 0.1"/hour
**Lake assumed initially full at spillway crest elevation 20.30 (top of dam = 36.3)

NOTES:

1. "Test Flood" computation based on COE guidelines.
2. The maximum capacity of the spillway without overtopping the top of the dam elevation (36.30) is equal to 84,480 CFS.
3. All discharges indicated are dependent upon the continued integrity of upstream storage reservoirs.
4. Surcharge storage is assumed to overtop the dam when exceeding the spillway capacity.
5. Test flood = Full PMF = 112 CSM = 141,500 CFS (D.A. = 1261 sq. miles).
6. Spillway crest elevation adopted = 20.30.
   (Spillway crest evelation adopted in Master Manual of Reservoir Regulation - Thames River Basin = 21.40).

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observation. The visual observations did not disclose any immediate stability problems; however, a thorough visual inspection of the dam could not be made because of water flow over the spillway crest.

6.2 Design and Construction Data. Drawings are available showing the layout of the dam and the cross-section of the rockfilled timber crib. No other design and construction data are available.

6.3 Post-Construction Changes. The Greenville Dam was built in 1882. Records indicate that replacement of the timber planking started about 1947. Damage occurred to the planking during the intense storms of 1955 and additional repair work was apparently performed. Other recorded repair works has been performed in 1965, 1969, 1978 and at the present time, April 1980. Records indicate that all of the foregoing repairs were to the timber spillway only.

6.4 Seismic Stability. This dam is in located in Seismic Zone 1 and in accordance with the recommended Phase 1 guidelines, does not warrant seismic stability analysis.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. Based on the observable portions of the Greenville Dam, the embankments and appurtenant structures are judged to be in FAIR condition. The condition of the timber crib spillway could not be evaluated due to the quantity of flow.

b. Adequacy of Information. The visual inspection was not adequate for a complete Phase 1 level of investigation.

c. Urgency. The recommendations and remedial measures described below should be implemented by the Owner within one year after receipt of this Phase 1 report.

7.2 Recommendations

The following items should be accomplished under the supervision of a qualified registered engineer, experienced in the design of dams and any recommendations developed from the analysis should be implemented by the Owner.

1. Conduct further hydrologic and hydraulic studies to determine inflow, outflow and overtopping potential for this dam taking into account the impact of the six Corps of Engineers flood control structures located upstream.

2. Recommendations pertaining to the spillway portion of the dam will depend on further visual inspection of the dam. The dam should be inspected when the upstream water level is below crest elevation.

3. Investigate the seepage existing at the downstream toe adjacent to the left abutment of the dam and develop a methodology to measure and control the flow.

4. Repair the erosion area at the left abutment. Complete the work modification which is in progress at this location and restore the crest profile to its original grade.

7.3 Remedial Measures

a. Operation and Maintenance Procedures.

1. Remedial measures pertaining to the spillway portion of the dam will depend on the results of further inspection of the dam.

2. Repair and restore to grade the construction roadway which has been cut in the left embankment. Grass should be planted on the restored surface.

3. Institute the technical inspection of the dam on an annual basis.

4. Develop and implement a regular maintenance program.

5. Develop an "Emergency Action Plan" that will include an effective pre-planned downstream warning systems. Items that should be identified in the plan should include the locations of emergency equipment, materials and manpower to reduce or minimize dam failure and/or overtopping, as well as, the authorities to contact including the Corps of Engineers. Potential downstream areas that would require evacuation should also be identified.

6. Implement a program of monitoring the dam during periods of flooding and other emergencies.

7. Cut the brush and weed growth from right embankment walls.

7.4 Alternatives

There are no alternatives to the measures listed above.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT Greenville Dam DATE April 17, 1980

TIME A.M.

WEATHER Fair

W.S.ELEV. 21.8 U.S. 9.2 D.S.

PARTY:

1. R. Brown, CEM Civil
2. E. Dessert, CEM Civil
3. R. Murdock, GEI Geotechnical
4. C. Rossoll, City of Norwich
5. A. Nystrom, City of Norwich
6. S. Khanna, CEM Hydrology & Hydraulics
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECKLIST

PROJECT Greenville Dam DATE April 17, 1980

INSPECTOR _____ DISCIPLINE _____

INSPECTOR _____ DISCIPLINE _____

AREA EVALUATED	CONDITION
DAM EMBANKMENT	Timber crib spillway section. Earth sections at the abutments.
Crest Elevation	20.3
Current Pool Elevation	21.8
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed.
Pavement Condition	Undulation along right side, left side covered with steel beams and concrete block.
Movement or Settlement of Crest	
Lateral Movement	None observed.
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Right abutment good. A road has been cut into the left abutment.
Indications of Movement of Structural Items on Slopes	None observed.
Trespassing on Slopes	Roadway and worn path on left side of dam. Erosion has occurred at the downstream toe.
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection	None
Unusual Movement or Cracking at or Near Toe	None observed.
Unusual Embankment or Downstream Seepage	Small seepage area observed along the downstream toe on left side of the dam.
Piping or Boils	None observed.
Foundation Drainage Features	None

PERIODIC INSPECTION CHECKLIST

PROJECT Greenville Dam DATE April 17, 1980

INSPECTOR _____ DISCIPLINE _____

INSPECTOR _____ DISCIPLINE _____

AREA EVALUATED	CONDITION
DAM EMBANKMENT (Cont.)	
Toe Drains	None
Instrumentation System	None
Vegetation	Grass well maintained along crest on right side of dam.

PERIODIC INSPECTION CHECKLIST

PROJECT Greenville Dam DATE April 17, 1980

INSPECTOR _____ DISCIPLINE _____

INSPECTOR _____ DISCIPLINE _____

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	
Slope Conditions	Overgrown with trees and brush.
Bottom Conditions	Not observable.
Rock Slides or Falls	None
Log Boom	None
Debris	Not observable. Many overhanging trees.
b. Intake Structure	
Condition of Concrete and Stone Masonry	Good
Stop Logs and Slots	None

PERIODIC INSPECTION CHECKLIST

PROJECT Greenville Dam DATE April 17, 1980

INSPECTOR _____ DISCIPLINE _____

INSPECTOR _____ DISCIPLINE _____

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	Timber superstructure. Mortared stone masonry foundation.
General Condition	Timber - Fair Stone foundation - Good
Condition of Joints	Good
Spalling	Not observable.
Visible Reinforcing	Not observable.
Rusting or Staining of Concrete	Not observable.
Any Seepage or Efflorescence	Not observable.
Joint Alignment	Good
Unusual Seepage or Leaks in Gate Chamber	Not observable.
Cracks	None observed.
Rusting or Corrosion of Steel	Stone masonry.
b. Mechanical and Electrical	3 electrically operated gates and 3 manual gates, all of timber. Rack and pinion lift mechanism with timber stem.
Crane Hoist	None
Hydraulic System	None
Service Gates	Timber
Emergency Gates	None
Lightning Protection System	None
Emergency Power System	None

PERIODIC INSPECTION CHECKLIST

PROJECT Greenville Dam DATE April 17, 1980

INSPECTOR _____ DISCIPLINE _____

INSPECTOR _____ DISCIPLINE _____

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	Not observable.

PERIODIC INSPECTION CHECKLIST

PROJECT Greenville Dam DATE April 17, 1980

INSPECTOR _____ DISCIPLINE _____

INSPECTOR _____ DISCIPLINE _____

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Mortared stone masonry arch openings
Spalling	None observed.
Erosion or Cavitation	None observed.
Any Seepage or Efflorescence	Not observable.
Condition at Joints	Good
Drain Holes	None observed.
Channel	
Loose Rock or Trees Overhanging Channel	Yes - trees.
Condition of Discharge Channel	Good

PERIODIC INSPECTION CHECKLIST

PROJECT Greenville Dam DATE April 17, 1980

INSPECTOR _____ DISCIPLINE _____

INSPECTOR _____ DISCIPLINE _____

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	Shetucket River.
General Condition	Good
Loose Rock Overhanging Channel	None observed.
Trees Overhanging Channel	Yes
Floor of Approach Channel	Natural river bottom.
b. Training Walls	Mortared stone masonry.
General Condition of Stone Masonry	Good
Any Seepage or Efflorescence	Yes - see embankment checklist.
Drain Holes	None observed.
c. Weir	Stone masonry and timber. Not observable.
d. Discharge Channel	Natural bed of Shetucket River
Loose Rock Overhanging Channel	None observed.
Trees Overhanging Channel	Yes
Floor of Channel	Natural bottom.
Other Obstructions	None

APPENDIX B

ENGINEERING DATA

APPENDIX B-1

Correspondence pertaining to the history, maintenance, and modifications to the Greenville Dam as well as copies of past inspection reports are located at:

State of Connecticut
Department of Environmental Protection
State Office Building
165 Capitol Avenue
Hartford, Connecticut 06115
Attention: Mr. Victor Galgowski,
Dam Safety Engineer

APPENDIX B-2

SELECTED COPIES OF PAST INSPECTION REPORTS

CITY OF NORWICH

DEPARTMENT OF PUBLIC UTILITIES

DAM FAILURE CONTINGENCY PLAN

A. In the event of the failure or pending failure of the Greenville or Occum dams, the Watch Engineer at the North Main Street Power Station is to notify:

1.	Norwich Police Department	889-1341 (Emergency)
2.	Federal Energy Regulatory Commission (FERC)	(212) 264-3687 (Office)
	During non-office hours call:	
	Mr. James Hebson	(201) 998-2845
	Mr. Martin Inwald	(516) 285-5964
3.	Connecticut Light & Power	423-4561

B. The Norwich Police Department shall in turn immediately notify:

1.	Norwich Fire Department	887-2521 (Emergency)
2.	Norwich Public Works Department	887-5113 (Days) 887-7300 (Nights)
3.	Connecticut State Police	848-1201
4.	Civil Defense Director, Miss Rita Frechette	887-1018 (Business) 889-1417 (Residence)
5.	Connecticut Department of Transportation	889-3301

C. The Connecticut Light & Power Company is to be requested to curtail the generation at their Scotland, Taftville (Ponemah), and Tunnel Hydro Stations to lessen the river flow.

2/8/79

BENJAMIN H. PALMER
HEPARD B. PALMER

CHANDLER & PALMER
CIVIL ENGINEERS
114-116 THAYER BUILDING
TELEPHONE TURNER 7-5640

MEMBERS AMERICAN AND CONNECTICUT SOCIETIES OF CIVIL ENGINEERS

DAMS
WATER SUPPLIES
SEWERAGE
APPRAISALS
REPORTS
SURVEYS

NORWICH, CONN.

July 16, 1963

Public Utilities Department
34 Shetucket Street
Norwich, Connecticut

Re: Greenville Dam

Gentlemen:

This afternoon I made an inspection of the Greenville Dam. This was located on the Shetucket River about amile and a half North of the center of Norwich. The water on the pond was about one foot below full pond. The Contractor had removed about 15 of the planks on one section of the spillway. These planks had split and deteriorated. I notaced two small leaks coming through the dam, one about halfway across the dam, and the other one perhaps, 75 feet out from the West abutt-ment. I recommend the following work to be done at once:

a). Replace these planks that are split and broken.

b). Fill in the back of the dam with good material from the bank on the East shore. This can be spread by means of a buildozer and tractor and all of the holes in the embankment should be filled up about 20 feet from the spillway. I believe that this material, thoroughly compacted will stop the leaks that are visible at present. I think that this is all that needs to be done at this time.

The Easterly half of the lowest apron shows considerable wear on the ends of the oak planks. While I don't think there is any danger involved at present, I think you should plan to replace these planks next year. Apparently the ice and debris have worn the planks off. The dam, in general, is in pretty good shape, but since it is a timber dam, it requires considerable maintenance and a number of these planks have not been out for at least 15 years.

If the work is carried out as outlined above, I believe the dam will be safe.

Very truly yours,

CHANDLER & PALMER

B. H. Palmer

BHP/nir
cc: State Water Resources Commission

January 31, 1969

Memo to: File

From: William H. O'Brien III

Subject: Greenville Dam - Norwich

The following is a summary of facts obtained from Mr. Albert F. Nystrom, Electrical Construction Superintendent for the Town of Norwich, Department of Public Utilities, owners of the dam, at a field inspection of the dam on January 15, 1959.

The present owners obtained the dam from the Norwich Water Power Company in 1961 or 62. Since that time, they have spent between $80,000 and $100,000 in repair work consisting primarily of replacement of rotted timbers downstream of the flashboards. Dry summers in the recent past had apparently accelerated deterioration from alternate wetting and drying. This work was done as it had been for the last 50 years by the Torrence Construction Co., Prospect Street, Norwich, John Vossler, owner. Practically all the exterior planking over which the water flows has been replaced. All wood used was native oak and work was done with the advice of Ben Palmer, Engineer, Norwich.

The following was carved into stone at the dam: "Built 1882 Hiram Cook, Pres & C. E., Directors: Frank Johnson, James D. Mowry, Charles P. Cogswell, Henry L. Parker"

The granite coping is in place as shown on cross section prints dated 1915, but there are now flashboards in place. There were 12 inch wide flashboards in place with reinforcing rods spaced 3½ feet apart for support. These rods were about 5 inches into the granite and 9" above with 2 x 3 braces for additional buttressing of boards at each support rod.

A set of plans was obtained from Mr. Nystrom for our records.

The dam appeared in very sound condition but it is recommended that the following work be done as part of routine maintenance.

1. Remove small maple tree on top of west earth abutment
2. Remove sapling growing from downstream face of west abutment
3. Remove trees on the east earth abutment
4. Replace some of horizontal planking at lowest level which has not yet been replaced. This is to be done as soon as they appear significantly weakened.

William H. O'Brien III
Civil Engineer

WHOIII:vhb.

CHANDLER & PALMER
CIVIL ENGINEERS
114-116 THAYER BUILDING
TELEPHONE 887-5640

MEMBERS AMERICAN AND CONNECTICUT SOCIETIES
OF CIVIL ENGINEERS

BENJAMIN H. PALMER
SHEPARD B. PALMER

NORWICH, CONN. 06360

DAMS
WATER SUPPLIES
SEWERAGE
APPRAISALS
REPORTS
SURVEYS

RECD 12-5-69
J. V.
W. A. L.
A. F. N.
W. W. G.
J. T. D.
H. F. L.
H. B. B.
J. C. P.
OTHER
FILE

December 4, 1969

Department of Public Utilities
Shetucket Street
Norwich, Connecticut

Attention: Mr. Robert E. Grimshaw

Dear Sir:

During the past month considerable repair work was done on the Greeneville Dam. This work was done by The Torrance Construction Company, and included a considerable amount of new planking on the middle apron and some planking on the slope.

During the work, a hole was discovered through the Dam which was allowing a considerable amount of leakage to come under the Dam and spill out below the lower apron. We put in various amounts of dye to try to trace this leak, and finally found the location. Generally speaking the location was about 161 feet west of the easterly abutment.

In this area new planking was put in on the upstream face of the Dam and 3 inch native oak planks were applied spiked to the timbers underneath. In some areas the timbers below were not in good condition. However, the planking was put on firmly and attached to the good areas. After the planking was put in the hole was again filled in and as far as we could tell, the leaks were substantially stopped. Mr. Nystrom of your Department has kept a careful record of the areas the planks were replaced or rebuilt.

I made several trips to the Dam during the construction period and believe the work was done satisfactorily and the Dam is in safe condition.

Very truly yours,

B H Palmer

Chandler & Palmer

BHP:mds

CITY OF NORWICH
DEPARTMENT OF PUBLIC UTILITIES

P. O. BOX 1008
34 SHETUCKET STREET
NORWICH, CONN. 06360

December 27, 1978

Mr. Victor F. Galgowski
Supt. of Dam Maintenance
State of Connecticut
Department of Environmental Protection
State Office Building
Hartford, Connecticut 06115

Re: Greenville Dam

Dear Mr. Galgowski:

Enclosed is a copy of the specifications and the drawing that were used when the repairs to the Greenville Dam went out to bid. The work actually done was as follows:

Item 1 (#1 on drawing) - replaced 113 sq. ft. of 3" plank

Item 2 (#2 on drawing) - replaced 775 sq. ft. of 4" plank

Item 3 (#5 on drawing) - replaced 1241 sq. ft. of 4" plank

Item 4c (#6 on drawing) - replaced 190 sq. ft. of 4" plank

Item 7 - replaced 100 linear feet of 8" x 12" timbers under surface - #5 on drawing.

We did not consider the work to be done as the type covered by Section 25-112 of the Connecticut General Statutes, so we did not apply for a permit.

Yours truly,

Charles F. Rossoll

Charles F. Rossoll, Manager
Electric Division

CFR/pas
cc: Mr.A.F.Nystrom, Supt.
Electric Production

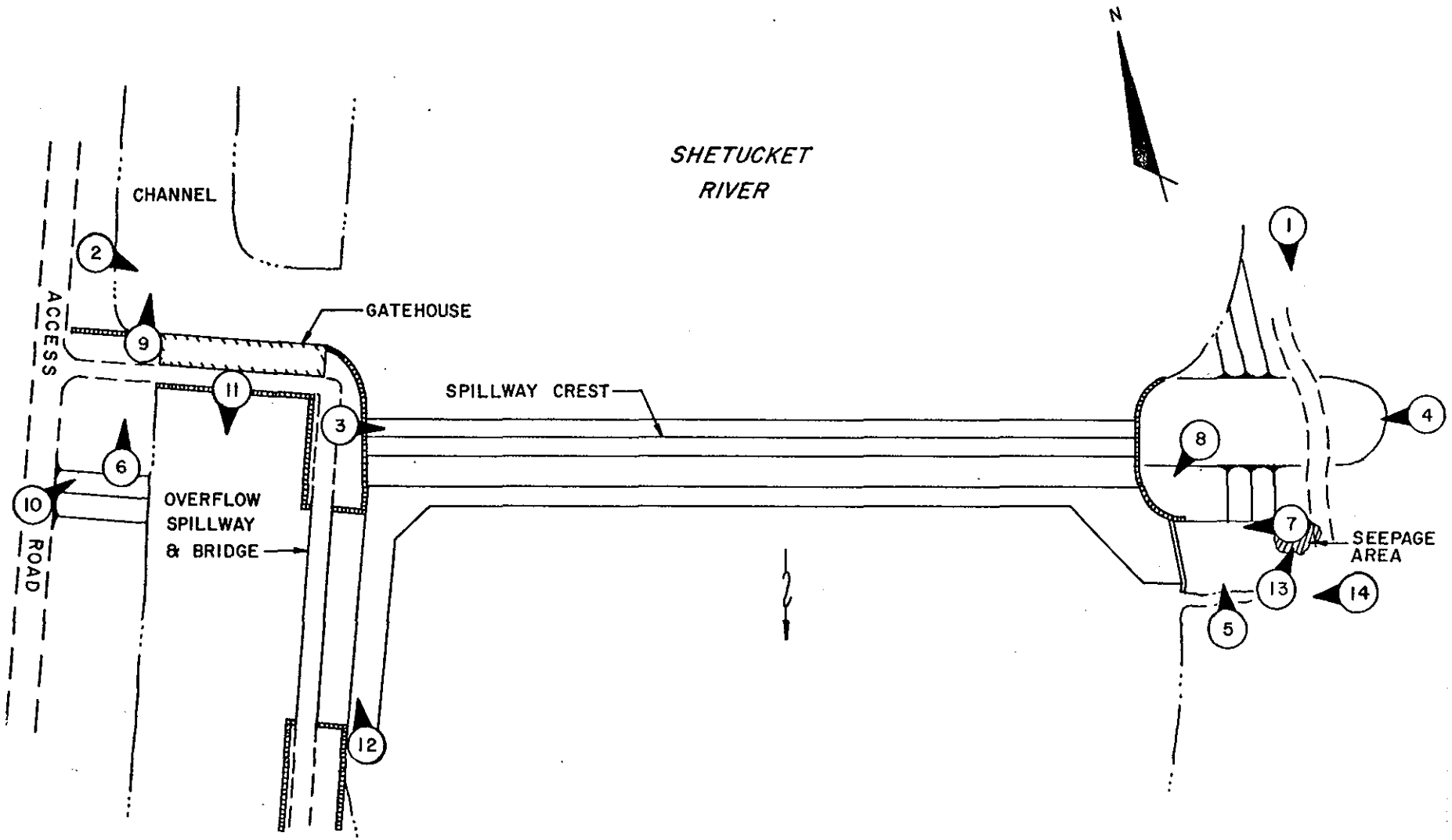
ENCL.

APPENDIX B-3

PLANS, SECTIONS AND DETAILS

APPENDIX C

PHOTOGRAPHS



PLAN

NOT TO SCALE

GREENVILLE DAM

PHOTO INDEX

PHOTO C-1 Upstream face of dam , left embankment.

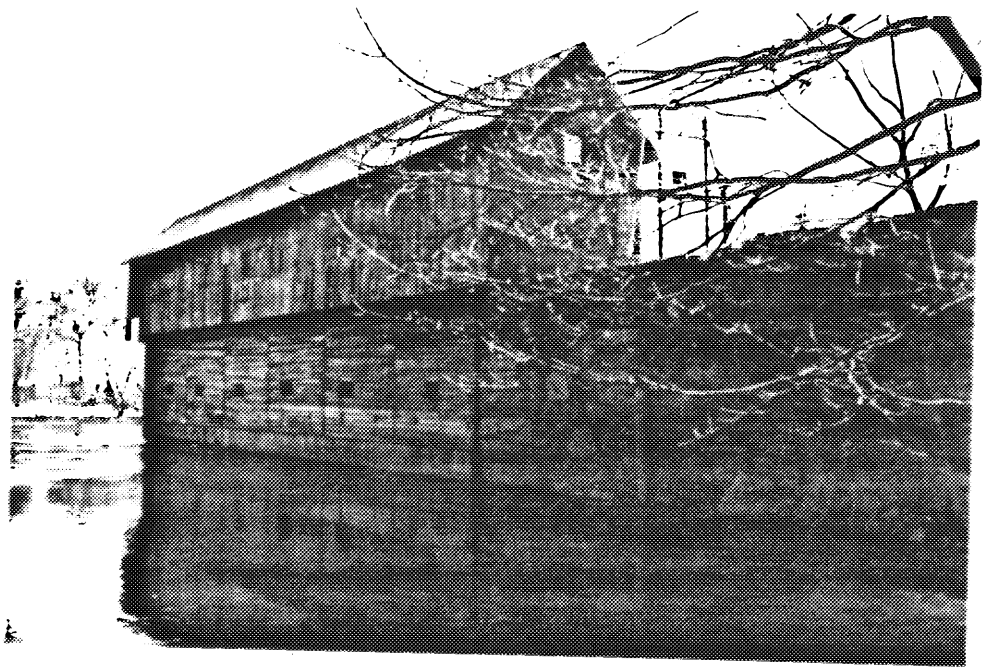


PHOTO C-2 Upstream face of dam, right embankment.

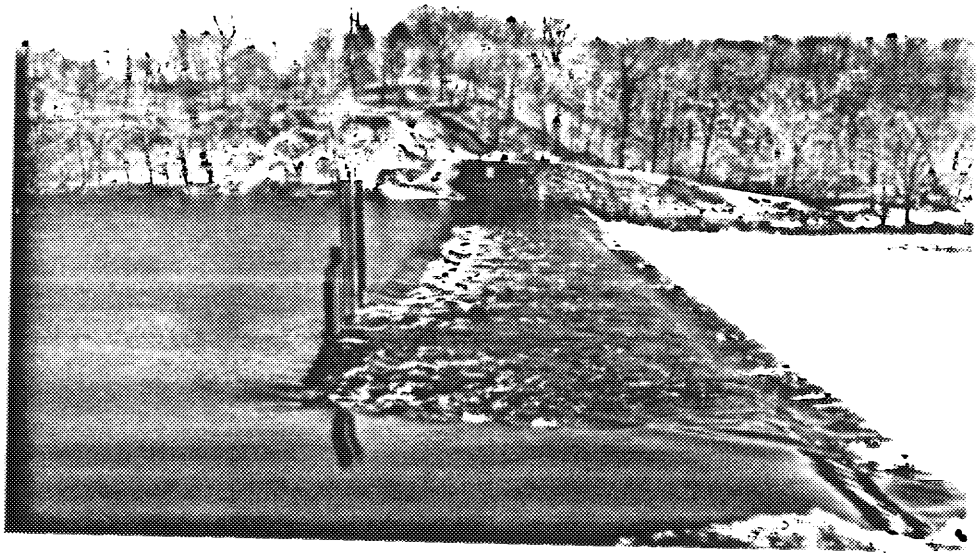


PHOTO C-3 Crest of spillway from right dam embankment.

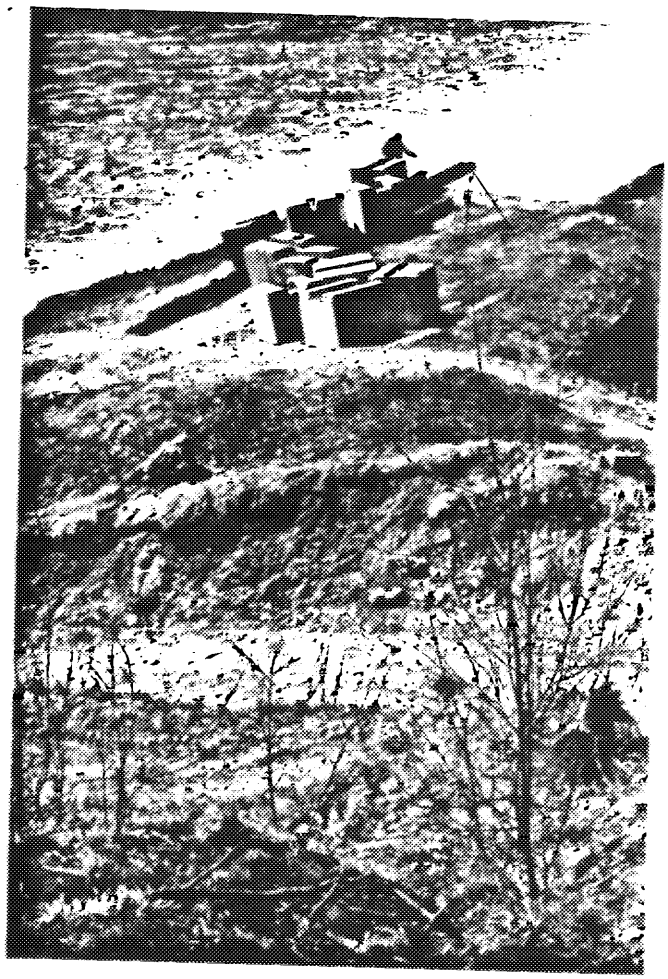


PHOTO C-4 Crest of dam embankment, left side.

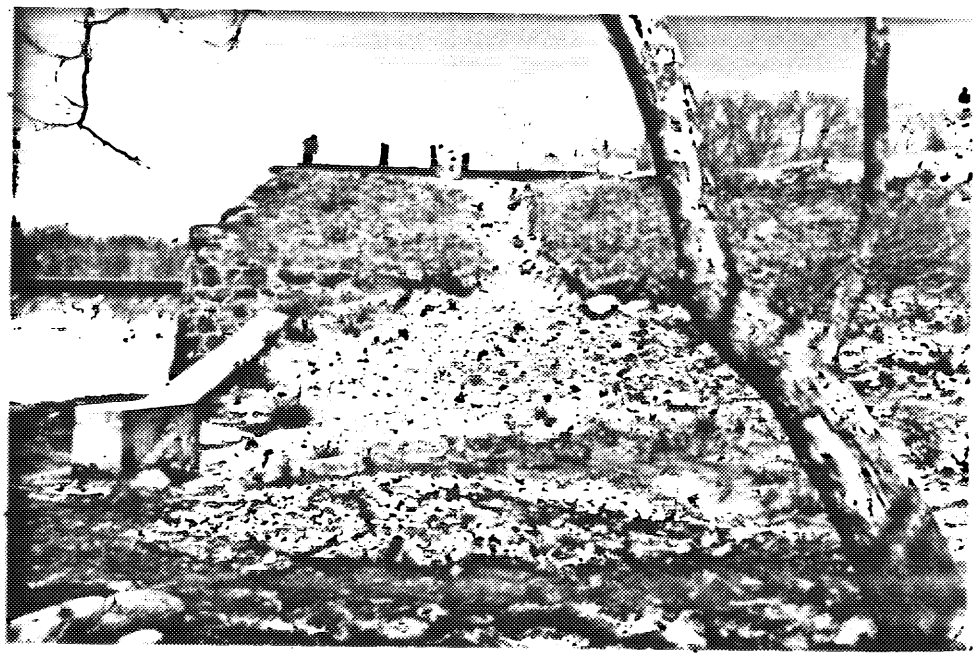


PHOTO C-5 Downstream face of embankment left side.

PHOTO C-6 Downstream face of dam (masonry) at right abutment.

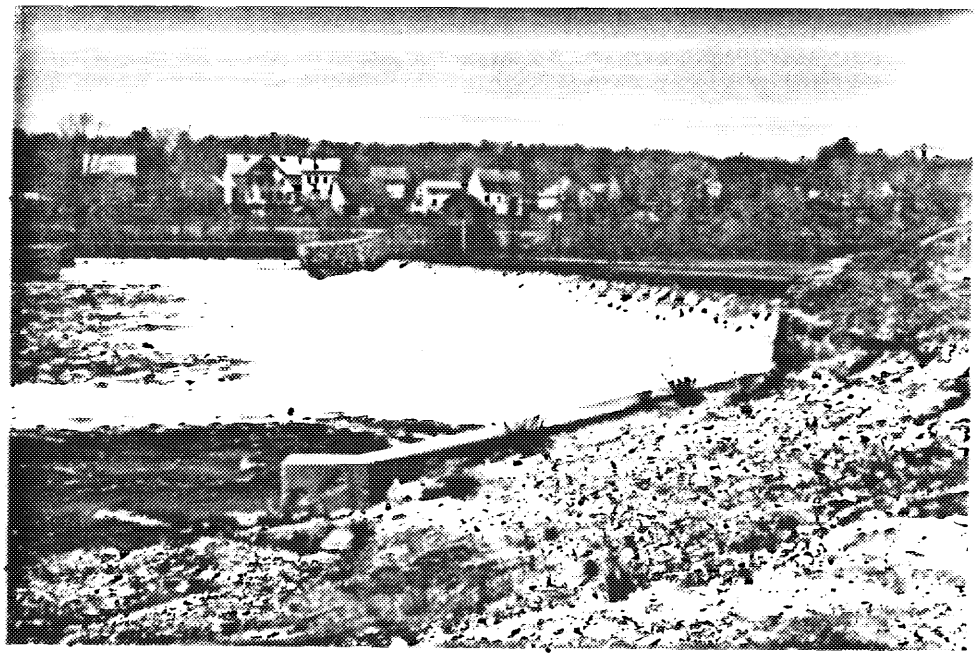


PHOTO C-7 Spillway from left side.

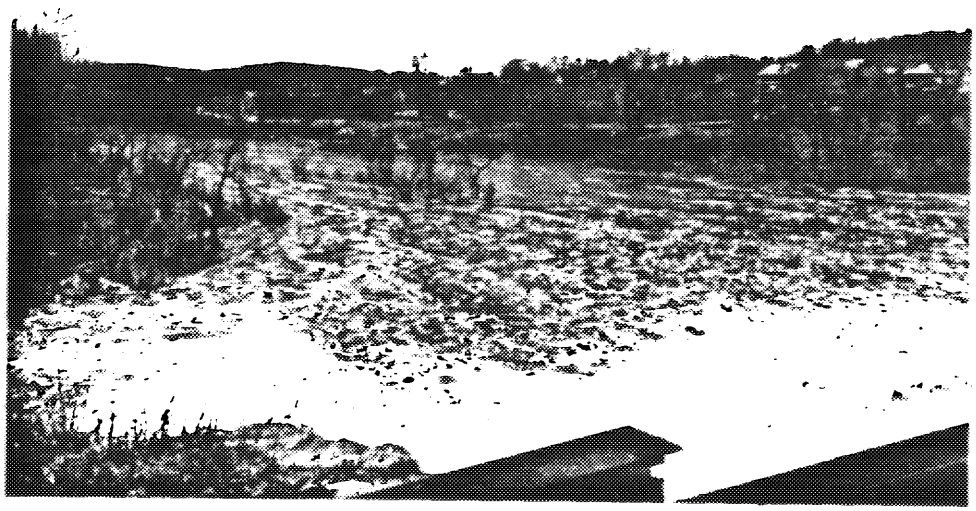


PHOTO C-8 Spillway discharge channel (Shetucket River) from left embankment.

PHOTO C-9 Intake channel.

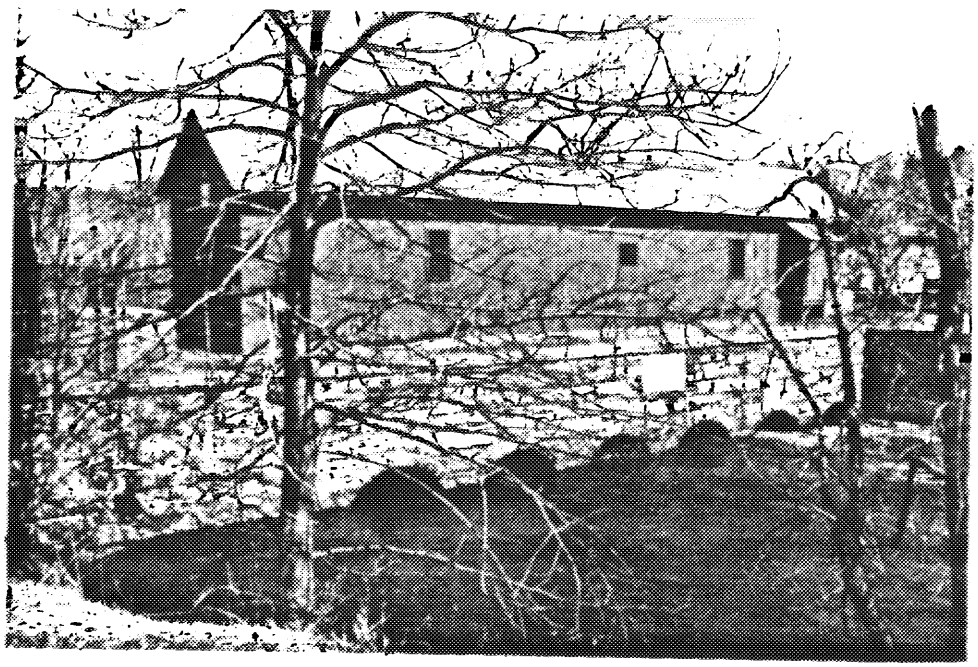


PHOTO C-10 Outlet works.

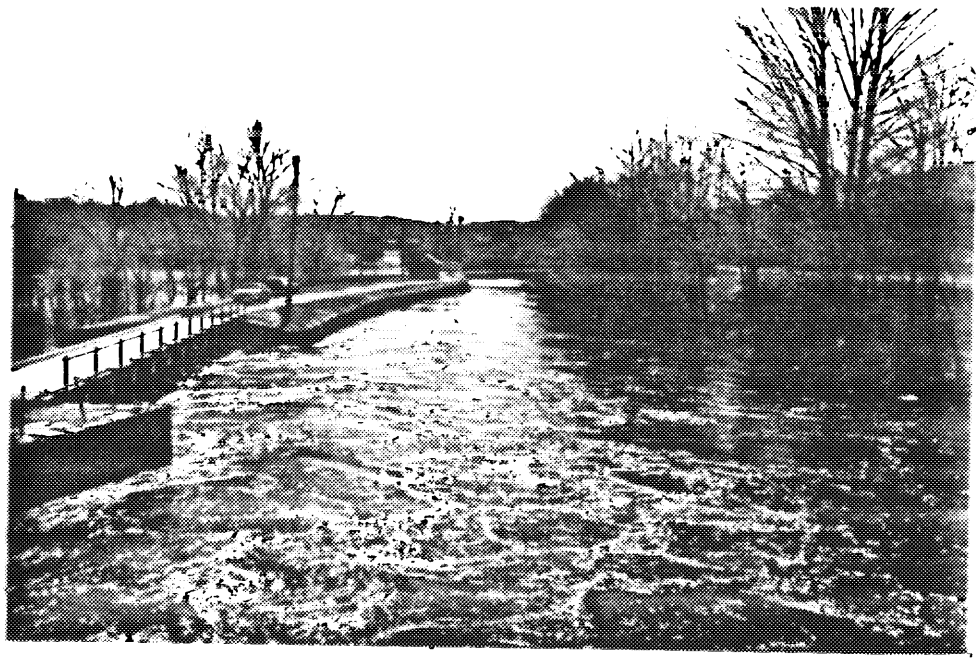


PHOTO C-11 Outlet channel.

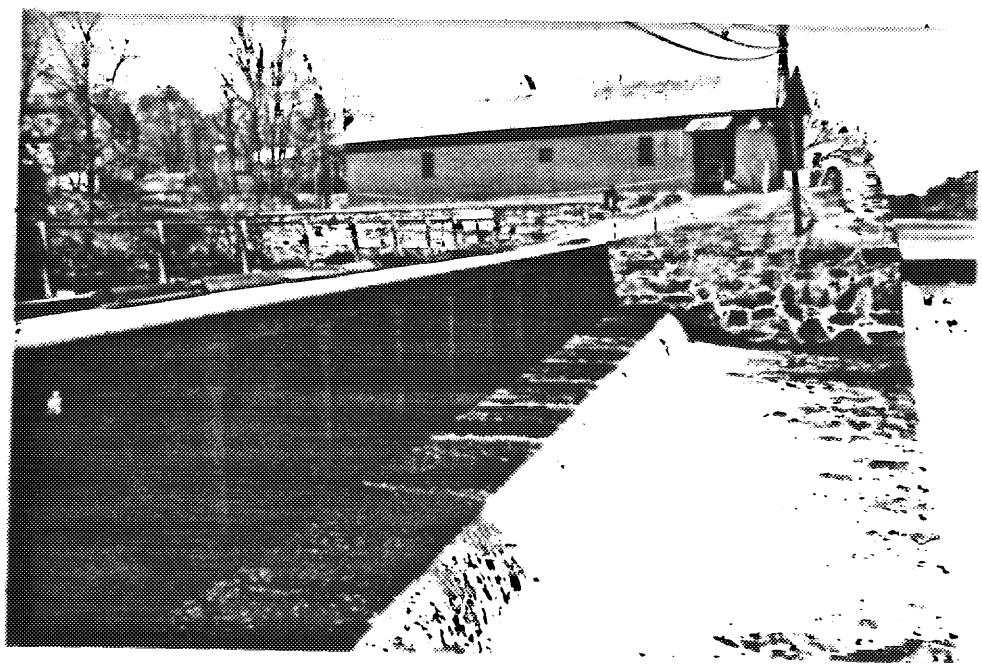


PHOTO C-12 Outlet channel spillway discharging to Shetucket River.

PHOTO C-13 Seepage area, left embankment.

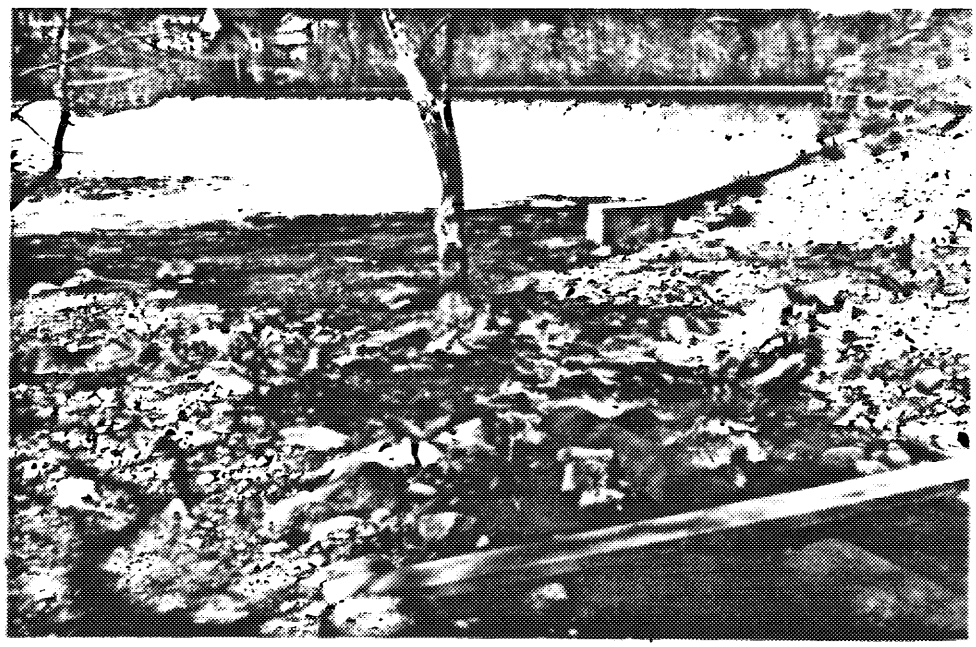
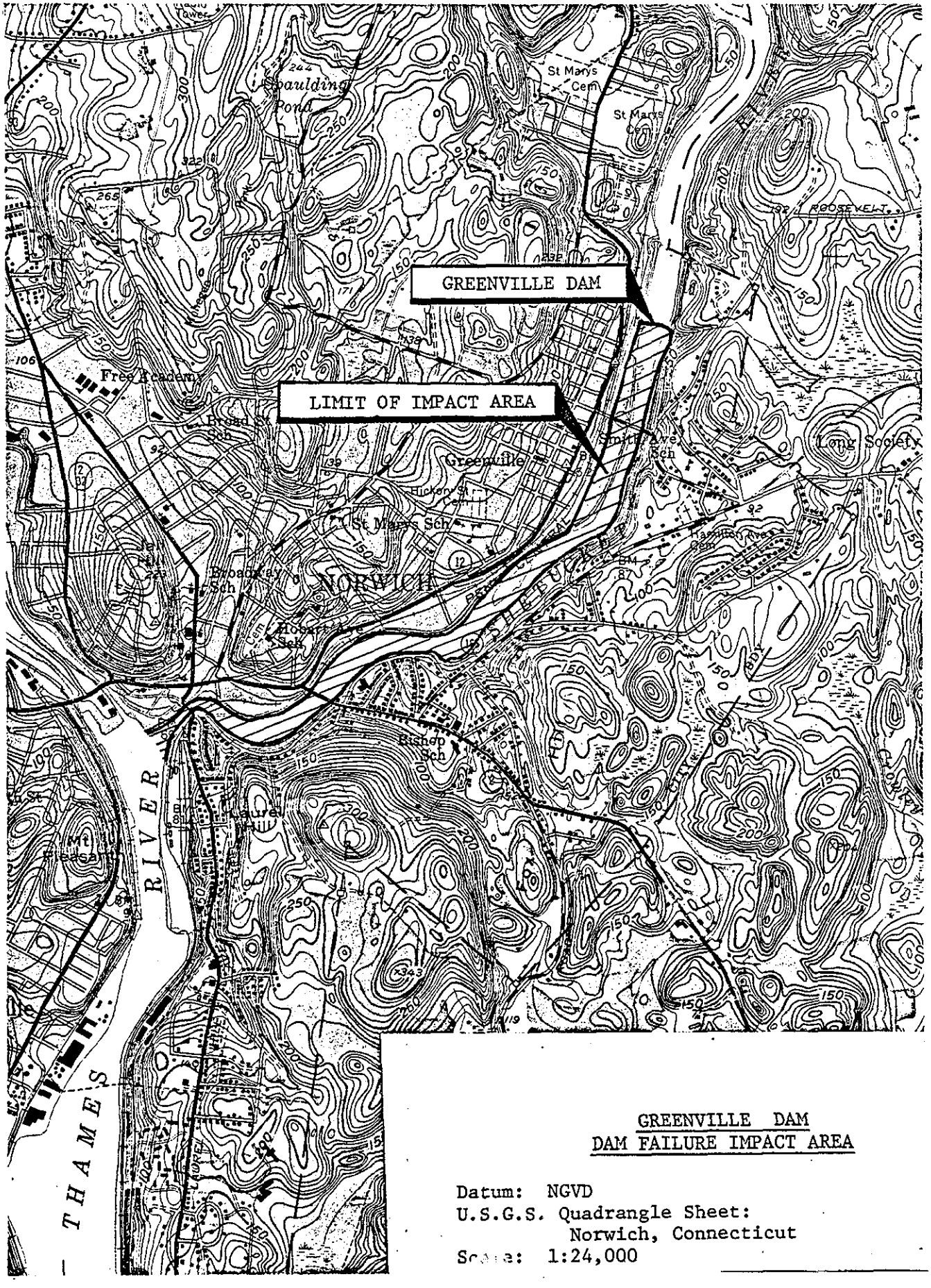


PHOTO C-14 Erosion area downstream of left embankment.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS



GREENVILLE DAM
DAM FAILURE IMPACT AREA

Datum: NGVD
U.S.G.S. Quadrangle Sheet:
Norwich, Connecticut
Scale: 1:24,000

Plate D-1A

A. Size Classification Greenville Dam

Height of dam = 27.0 ft.; hence Small

Storage capacity at top of dam (elev. 36.30) = 3200 AC-FT.; hence Intermedia

Adopted size classification INTERMEDIATE

B. Hazard Potential

This dam is classified as a HIGH hazard potential structure because its failure could result in loss of many lives; damages and inundation of many dwellings and commercial properties in the City of Norwich; damage to the support structures for the 8th Street, Main Street (Rt 2), Route 12, Water Street and Amtrack Railroad bridges; as well as temporary disruption of traffic and utility services located within or along these roadways. Loss of the dam will also prevent the generation of electricity by the City of Norwich.

C. Adopted Classifications

HAZARD	SIZE	TEST FLOOD RANGE
HIGH	INTERMEDIATE	Full PMF

Adopted Test Flood = Full PMF = 112 CSM

= 141,500 CFS

D. Overtopping Potential

Drainage Area = 1261 sq. miles

Spillway crest elevation = 20.30 ± NGVD

Top of Dam Elevation = 36.30 ± NGVD

Maximum spillway discharge Capacity without overtopping of dam = 84480 CFS

"test flood" inflow discharge = 141,500 CFS

"test flood" outflow discharge = 140,000 CFS

% of "test flood" overflow carried by spillway without overtopping = 60.3

"test flood" outflow discharge portion which overflows over the dam = 55520

% of test flood which overflows over the dam = 39.7%

Estimating Maximum Probable Discharges - Inflow and Outflow Values Date of Inspection: April 17, 1980

Name of Dam Greenville Dam ; Location of Dam Shetucket River ; Town Norwich, CT

Watershed Characterization Rolling terrain; swampy; reservoirs; moderate to flat slopes. ; 126.1 sq. miles of drainage area is swampy or occupied by storage reservoirs

Adopted "test" flood = Full PMF = 112 CSM = 141,500 CFS; Re = Effective Rainfall = 19 inches

D.A. = Drainage Area (Gross) = 1261 Square Miles; Basin Slope = 0.004 hence; Flat

S.A. = Surface Area of Reservoir = 0.25 (160 Acres) Square Miles; Time of Concentration = more than one day

Shape and Type of Spillway = Free overflow sharp crest weir; Timber cribbing with stone filling

B = Width of Spillway = 400 feet; C = Coefficient of Discharge = (3.33-Friction) = 3.30

Maximum Capacity of Spillway Without Overtopping = 84480 CFS = 60.3 % of test flood

Top of Dam Elevation = 36.3 ± ; Spillway Crest Elevation = 20.3 ± (main spillway)

Overflow portion of Length of Dam = 664 ; C = Coefficient of discharge for Dam = 3.3

Name of Dam	Test Flood Q_p		Inflow Characteristics		Outflow Characteristics First Approximation			Outflow Characteristics Second Approximation			Outflow Characteristics Third Approximation (Adopted)		
	CSM	CFS	h_0 in feet	S_0 in in.	Q_{p1} CFS	h_1 in ft.	S_1 in in.	S_2 in in.	h_2 in ft.	Q_{p2} CFS	S_3 in in.	h_3 in ft.	Q_{p3} CFS
1	2	3	4	5	6	7	8	9	10	11	12	13	14
	PMF = 112	141,500	23.00	0.06	–	–	–	–	–	–	0.054	22.2	140,000
					–	–	–	–	–	–			

Q_p = Discharge; h= Surcharge height; S = Storage in inches

NOTE: Outflow discharge values are computed as per COE guidelines.

D13

NAME OF DAM: GREENVILLE DAM

ESTIMATING EFFECT OF SURCHARGE STORAGE ON "TEST FLOOD"

A. This routing of floods through the reservoir was carried out according to the guidelines established by the Corps of Engineers in Phase 1 Inspection for Dam Safety Investigations issued in March, 1978.

B. Formulas used are as follows:

i. For no overtopping: $Q = C_1 B_1 h_1^{3/2}$
For overtopping: $Q = C_1 B_1 [h_2 + F.B.]^{3/2} + C_2 B_2 h_2^{3/2}$
For open channel flow: N/A
For orifice flow: N/A

where C_1 = coefficient of discharge for spillway; B_1 = length of spillway
C_2 = coefficient of discharge for dam; B_2 = length of dam
h_1 = head over spillway crest (feet); h_2 = head over dam (feet)
F.B. = distance between spillway crest and top of dam

ii. Surcharge storage in inches = $S = 12 (h_1 + h_2) \frac{S.A.}{D.A.}$ =
where S.A. = surface area =
D.A. = drainage area in sq. miles

iii. $Q_{outflow} = Q_{inflow} (1 - \frac{S}{Re})$; where Re = effective rainfall =

iv. Length of dam = 400 ft. ; Top of Dam elev. = 36.3 ; c for dam = 3.3
Length of spillway = 400 ft. ; Spillway crest el. 20.3 ; c for spillway = 3.3

$Q = 3.3 \times 400 h^{1.5}$ where h is head over top of spillway crest
S = storage in inches = $12h \frac{S.A.}{D.A.} = 0.0024h$

v. Q_{inflow} = 141,500 C.F.S.

Q in CFS	Elevation	Total Head over crest $h_1 + h_2 = h$	Storage in inches = S	Remarks
141,284	32.3	12.0	0.029	
141,246	34.3	14.0	0.034	
141,217	36.3	16.0	0.038	
141,187	38.15	17.85	0.042	
141,179	38.3	18.0	0.043	
141,142	40.3	20.0	0.048	
141,097	42.5	22.2	0.054	

"Rule of Thumb Guidance for Estimating Downstream Dam Failure Discharge"

BASIC DATA

Name of dam Greenville Dam Name of town Norwich, CT

Drainage area = 12.61 sq. mi., Top of dam 36.3 ± NG

Spillway type = Free overflow weir type Crest of spillway 20.3 ± NGV

Surface area at crest elevation = 160 Acres = 0.25 sq. mi.

Reservoir bottom near dam = 7.3 NGVD

Assumed side slopes of embankments 2:1

Depth of reservoir at dam site 29.0 = y_o = 27.0 f

Mid-height elevation of dam = 23.0 NG

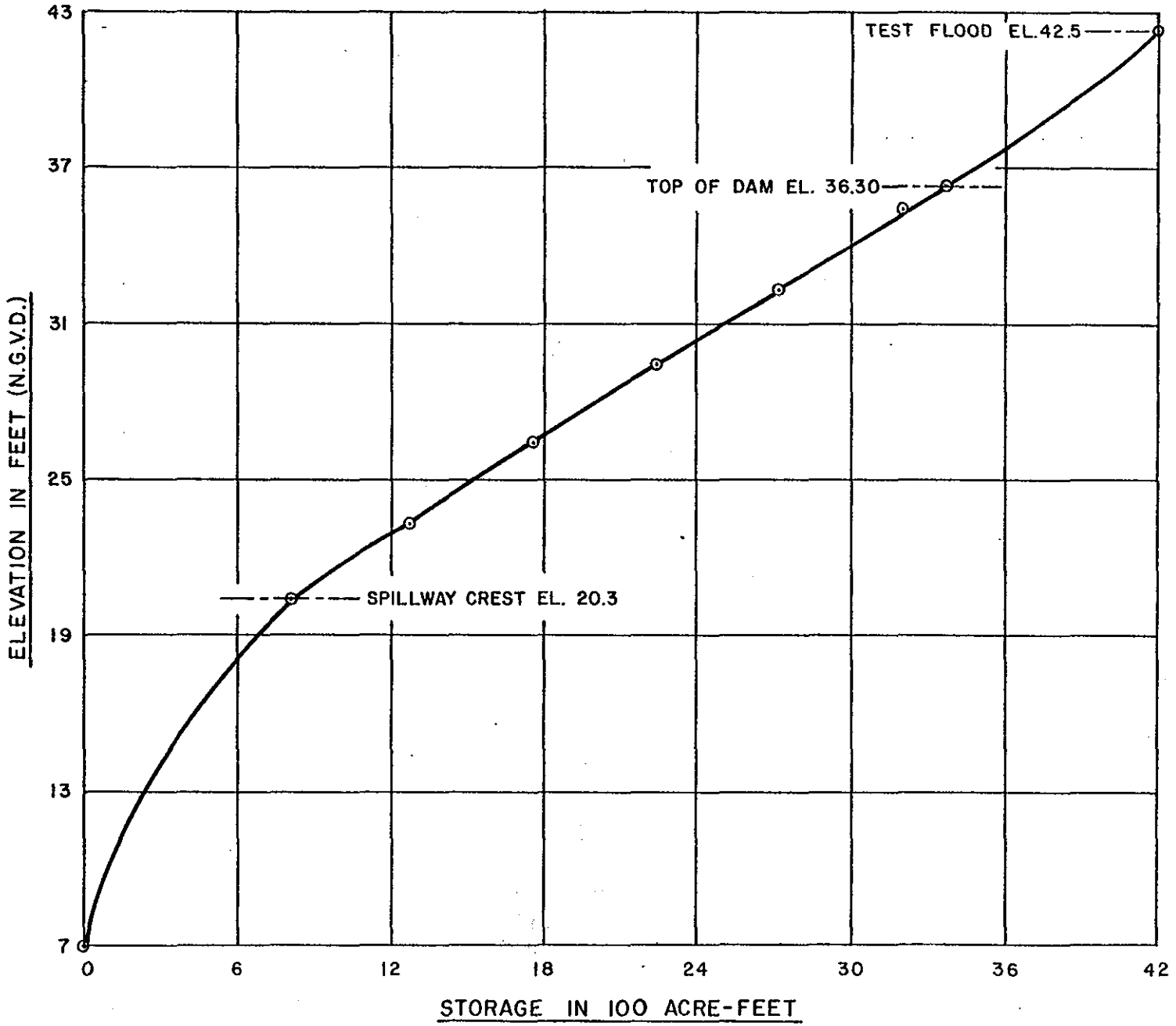
Length of dam at crest = 400 ft.

Length of dam at mid-height = 400 ft.

50% of dam length at mid-height = W_b = 200 ft.

Width of channel immediately downstream = B = 200 ft.; Shape of breach = rectangular

Elevation (NGVD)	Estimated Storage in AC-FT	
20.30	800	Spillway Crest Elevation
23.30	1280	
26.30	1760	
29.30	2240	
32.30	2720	
35.30	3200	
36.30	3360	Top of Dam Elevation
38.15	3656	
42.50	4200	Test Flood Elevation



STORAGE-ELEVATION CURVE
GREENVILLE DAM

PLATE D-6

GREENVILLE DAM

i. DAM FAILURE ANALYSIS

A. Failure Analysis

Discharge $= \frac{8}{27} W_B \sqrt{g}\, y_o^{1.5}$ C.F.S.

$= 1.68\, W_B\, y_o^{1.5}$

$= 47140$ C.F.S.

B. Maximum Spillway

Discharge with W.S.E.

At top of Dam @ 36.30 84480 C.F.S.

C. Total Dam Failure Discharge 131720 C.F.S.

D. Reservoir - Storage Data:

Volume of storage at spillway crest = 800 AC-ft. @ Elev. 20.30

Surcharge storage at top of dam = 2560 AC-ft. @ Elev. 36.30

Storage Total = 3360 AC-ft. @ Elev. 36.30

E. Flood Discharge Channel

i. Maximum depth of flow just D/S of Dam = $\frac{4}{9} y_o$ = 12.0 feet

Notes:

1. Failure of dam is assumed to be instantaneous. When pool reaches top of dam, and is a full-depth partial width rectangular shape failure with a width of failure = W = 200 feet and depth of failure y_o = _____ 27 feet.
2. Steady, uniform flow phenomenon is assumed for determination of failure profile and is based on Manning's formulae.
3. Failure profile for impacted area determination is determined at one typical cross section in the downstream channel. Reduction in discharge due to available storage has been taken into account.

ii. Reach 1

Length = 11000 feet; Station 0 to Station 110+00; n = 0.05

Bed slope = $S_o \simeq S_f$ = 0.0017; Bed width = b = 664 feet

Bed width is scaled from U.S.G.S. map; scale 1" = 2,000 feet

As bed width is large and 1" = 2,000 feet and 10-foot contour interval scale maps are being used for various channel parameters, it is appropriate to assume that d = R = Hyd Radius = depth, hense Manning's formulae is transformed:

$$Q = A \frac{1.49}{n} R^{2/3} \sqrt{S} = bd \frac{1.49}{n} d^{2/3} \sqrt{S}$$

$$Q = b \frac{1.49}{n} \sqrt{S}\, d^{5/3} = Kd^{5/3} = 825 d^{5/3}$$

State Discharge Relationship for Reach 1

Depth = d in Feet	Stage of Elevation	Discharge in CFS = Q	Velocity in ft./sec.	Storage Volume in AC-ft. = V
0	6.3	0	0	0
2	8.3	2618	1.97	335
6	12.3	16325	4.09	1005
10	16.3	38234	5.76	1675
14	20.3	66973	7.20	2345
18	24.3	85085	8.52	3015
21	27.3	131604	9.43	3517

F. Water surface profiles resulting from maximum spillway discharge and also from dam failure discharge are shown on Plate D-13 for comparison purposes. This figure also shows the rise in water depth due to failure of dam.

Also, Discharge -- Depth and Storage-depth curves are shown on Plate D-14 for downstream channel.

Notes: 1. Storage volume in AC-ft = $\frac{\text{(Length of Reach) (Bed Width) (Depth)}}{43{,}560}$

2. Failure discharge being large will mostly be overbank flow on existing channel.

G. For Q_1 = 131720 CFS; depth = 21.0 ft. V_1 = 3517 AC-ft.

Trial $Q_2 = Q_1 \left(1 - \frac{V_3}{\text{Storage}}\right) = \left(1 - \frac{3517}{3360}\right) =$ 0 CFS

V_2 = 0 AC-ft.

Avg $V = \frac{V_1 + V_2}{2}$ = AC-ft.

$Q_2 = Q_1 \left(1 - \frac{V \text{ Avg.}}{\text{Storage}}\right)$ = 62800 CFS; y_2 = 13.5 ft.

Depth at center of flood as adopted = $\frac{21 + 13.5}{2}$ = 17.2 ft.

Additional dam failure analysis beyond Reach 1 has not been undertaken because the depth of flow 17.2 feet at the end of Reach 1 will not cause any additional hazardous conditions further downstream. The failure discharge and depth will continually decrease beyond Reach 1. However almost total impacted area due to failure of dam is shown on Plate D-13. The depth of flow before failure of dam is 18.0 feet which is greater than 17.2 feet.

SUMMARIZED AND ADOPTED VALUES

FOR

DAM FAILURE ANALYSIS

i. Name of Dam GREENVILLE DAM

ii. Dam Failure Discharge _____ = 47140 cfs.

iii. Maximum Spillway Discharge _____ = 84480 cfs.

iv. Total Dam Failure Discharge _____ = 131720 cfs.

v. Normal (Manning Depth) for 131720 = 21.0 feet

vi. Normal (Manning Depth) for 84480 = 18.0 feet

vii. Increase in depth due to failure of dam = 3.0 feet

viii. W.S.E. prior to failure = Ground Elevation + 18.0

ix. W.S.E. after failure = Ground Elevation + 21.0

Note: The adopted depth of flow values are assumed to be accurate representations of damages in the impacted areas. Professional judgement is used in these final adopted values.

Greenville Dam

COMPUTATIONS FOR
SPILLWAY RATING CURVE AND
OUTLET RATING CURVE COMPUTATIONS

Spillway width = 400 feet; Spillway crest elevation = 20.3 NGVD

Length of dam = 400 feet; Top of dam elevation = 36.3 NGVD

C = 3.3

i) MAIN SPILLWAY RATING CURVE COMPUTATIONS

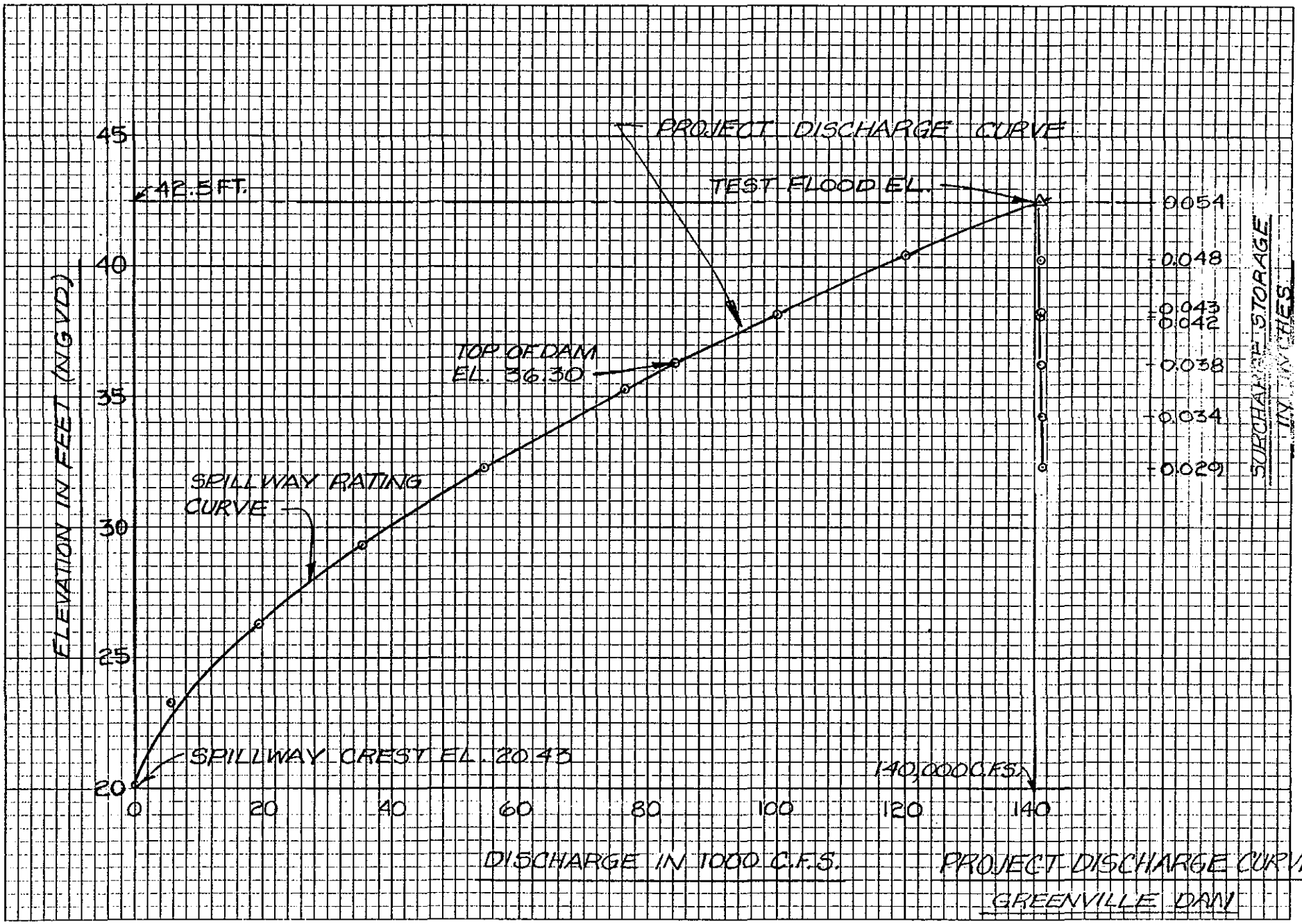
Elevation (ft.) NGVD	Spillway Discharge (CFS)	Remarks
20.30	0	Spillway Crest Elevation
23.30	5859	
26.30	19400	
29.30	35640	
32.30	54871	
35.30	76685	
36.30	84480	Top of Dam Elevation
38.15	100,000	
40.5	120,000	
42.5	140,000	Test Flood Elevation

ii) OUTLET RATING CURVE COMPUTATIONS

Elevation (ft.) NGVD	Discharge (CFS)	Remarks
9.30	0	Invert Elevation of Outlets
15.30	3000	
19.68	5958	Side Spillway Crest Elevation
20.30	7348	Main Spillway Crest Elevation
23.30	9000	
26.30	10392	
29.30	11619	
32.30	12728	
35.30	13748	
36.30	14071	Top of Dam Elevation
38.15	14651	
42.50	15600	Test Flood Elevation

Size of outlet = 6 - 10'x10' (est.); Area of outlet = 600 sq. ft.

Invert of outlet = 9.30; Center line of outlet = 14.30



PROJECT DISCHARGE CURVE
GREENVILLE DAM

PLATE D-12

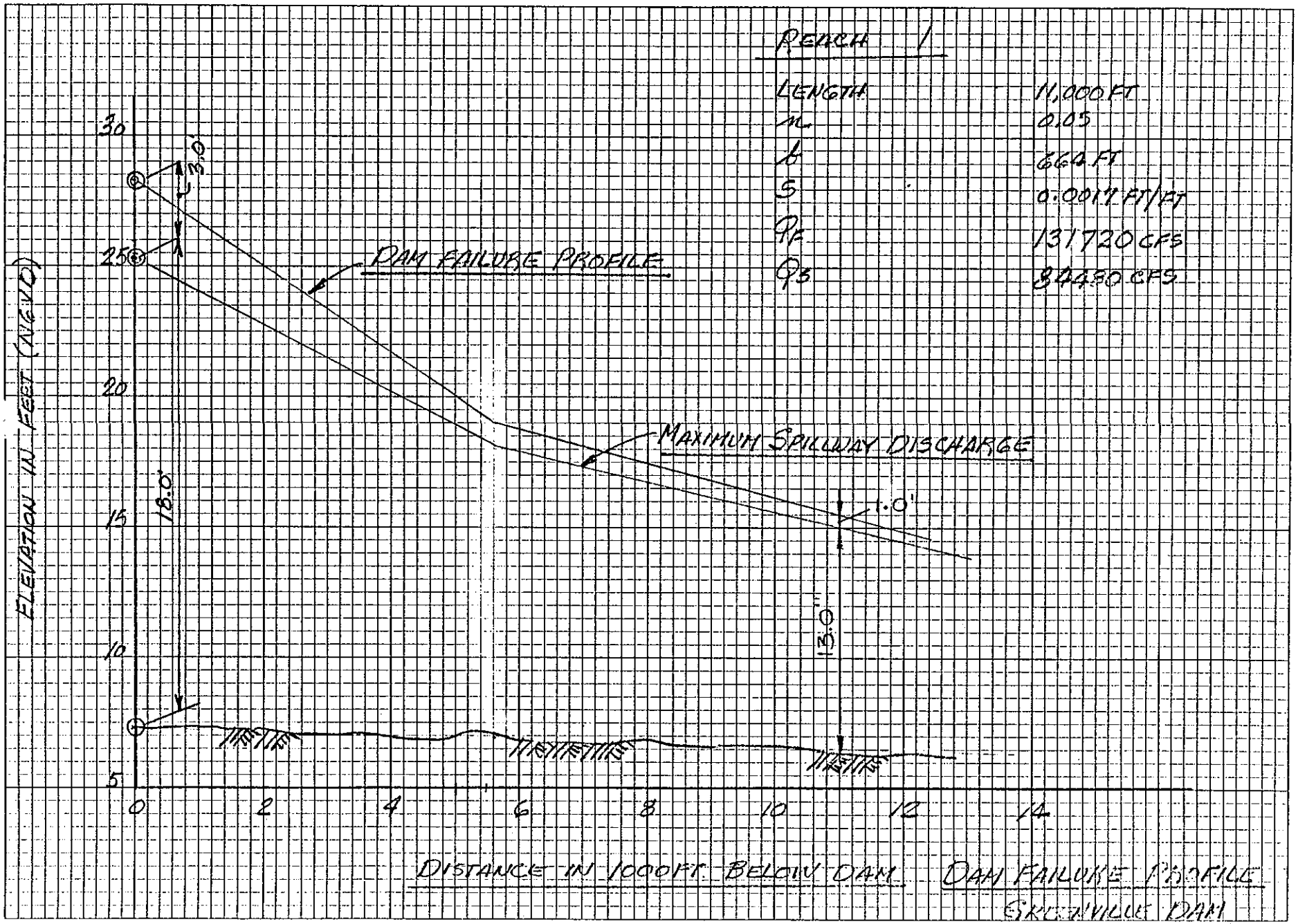


PLATE D-13

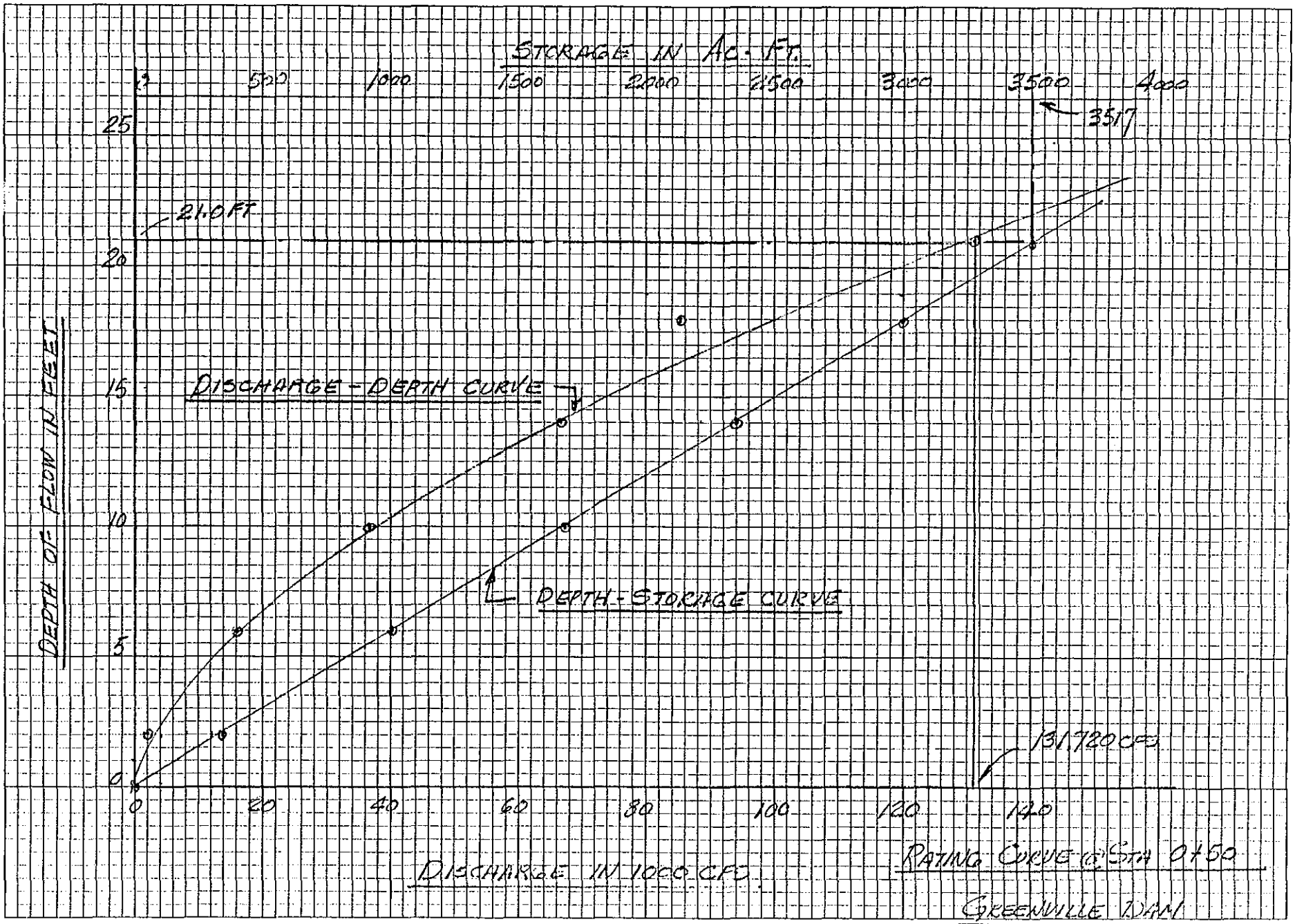
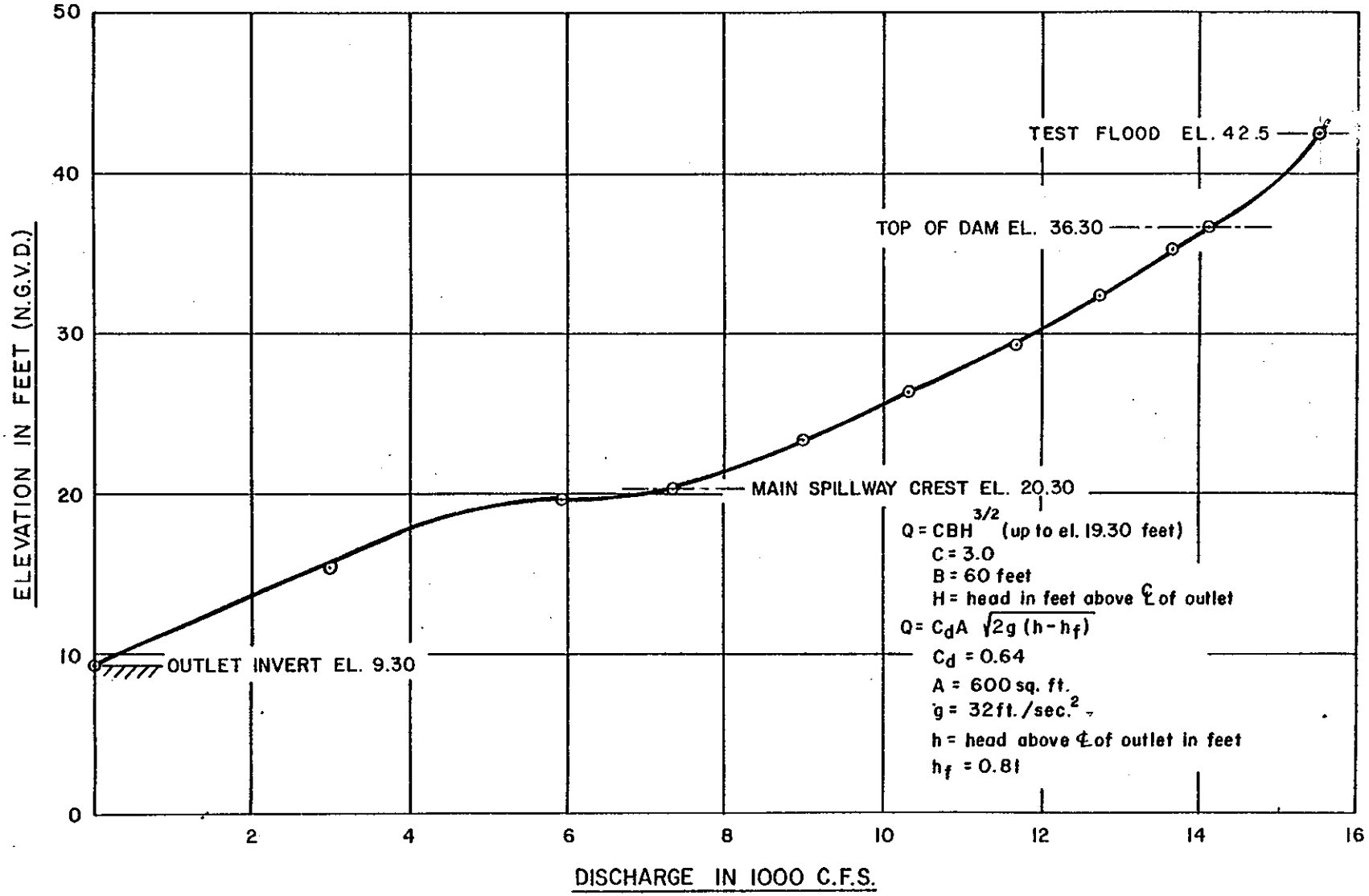


PLATE D-14



OUTLET RATING CURVE
GREENVILLE DAM

PLATE D-15

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(1) IDENTITY NUMBER	(2) DIVISION	(3) STATE	(4) COUNTY	(5) CONGR DIST	(6) STATE	(7) COUNTY	(8) CONGR DIST.	(9) NAME	(10) LATITUDE (NORTH)	(11) LONGITUDE (WEST)	(12) REPORT DATE DAY	MO	YR
09	206	NED	CT	011	02				GREENVILLE DAM	4132.3	7203.1			

(13) POPULAR NAME	(14) NAME OF IMPOUNDMENT
	SHETUCKET RIVER

(15) REGION	(16) BASIN	(17) RIVER OR STREAM	(18) NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	(19) DIST FROM DAM (MI.)	(20) POPULATION
01	10	SHETUCKET RIVER	GREENVILLE	1	3000

(21) TYPE OF DAM	(22) YEAR COMPLETED	(23) PURPOSES	(24) STRUCTURAL HEIGHT (FT.)	(25) HYDRAULIC HEIGHT (FT.)	(26) IMPOUNDING CAPACITIES MAXIMUM (ACRE–FT.)	(27) IMPOUNDING CAPACITIES NORMAL (ACRE–FT.)
PGOT	1882	H	29	27	3360	800

DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
NED	N	N	N	N	

(28) REMARKS
21=WOOD CRIB STONE FILLED 23=WATER STORAGE FOR D/S PLANT

(29) D/S HAS	(30) SPILLWAY CREST LENGTH	(31) SPILLWAY TYPE	(32) SPILLWAY WIDTH (FT.)	(33) MAXIMUM DISCHARGE (FT.)	(34) VOLUME OF DAM (CY)	(35) POWER CAPACITY INSTALLED (MW)	(36) POWER CAPACITY PROPOSED (MW)	(37) NAVIGATION LOCKS NO.	(38) LENGTH (FT.)	(39) WIDTH (FT.)	(40) LENGTH (FT.)	(41) WIDTH (FT.)	(42) LENGTH (FT.)	(43) WIDTH (FT.)	(44) LENGTH (FT.)	(45) WIDTH (FT.)
1	664	U	400	84480												

(46) OWNER	(47) ENGINEERING BY	(48) CONSTRUCTION BY
CITY OF NORWICH CT		

(49) REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE

(50) INSPECTION BY	(51) INSPECTION DATE DAY | MO | YR	(52) AUTHORITY FOR INSPECTION
CE MAGUIRE INC	07APR80	PL 92-367

(53) REMARKS

APPENDIX F

PERTINENT DATA FROM THE MASTER MANUAL OF RESERVOIR REGULATIONS - THAMES RIVER BASIN, CONNECTICUT

recession side of the main Quinebaug River hydrograph. The studies also indicated that the local areas immediately above the damage centers in the Quinebaug basin are the prime contributors to the peak flows

31. STANDARD PROJECT FLOODS

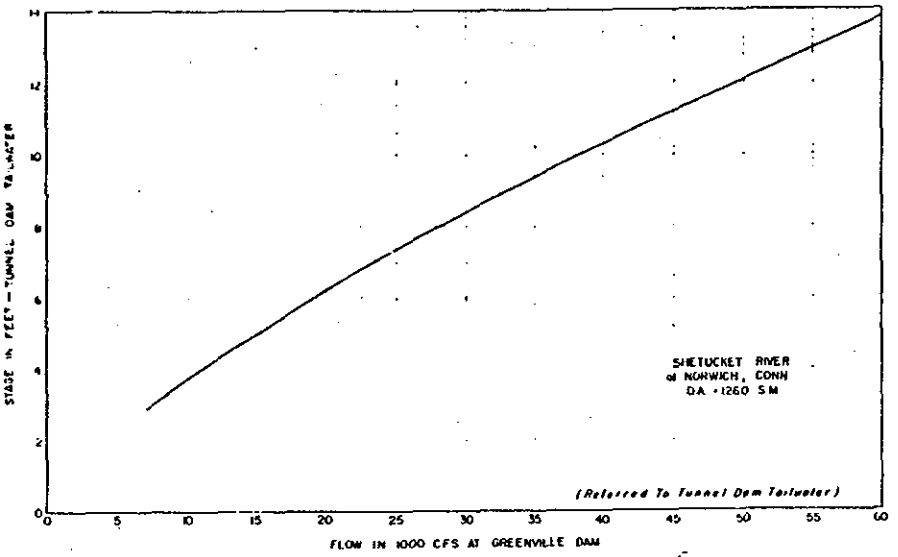
Examination of the records of great storms in the Thames River basin and adjacent watersheds indicates that somewhat greater floods than those previously experienced may be expected to occur in the future, therefore, standard project floods were developed to be used as a guide in determining flood control requirements in the basin. Due to geographical distribution of the damage centers, two standard project floods were developed, one with the storm centered over the upper Quinebaug River basin and the second, with the storm centered over the Willimantic River. Standard project storm rainfall was determined as described in Civil Engineer Bulletin 52-8. Standard project flood hydrographs were determined by means of unit hydrographs and flood routings. Standard project flood peak discharges for selected points within the Thames River basin are shown in table 7 and on plates 16 and 18.

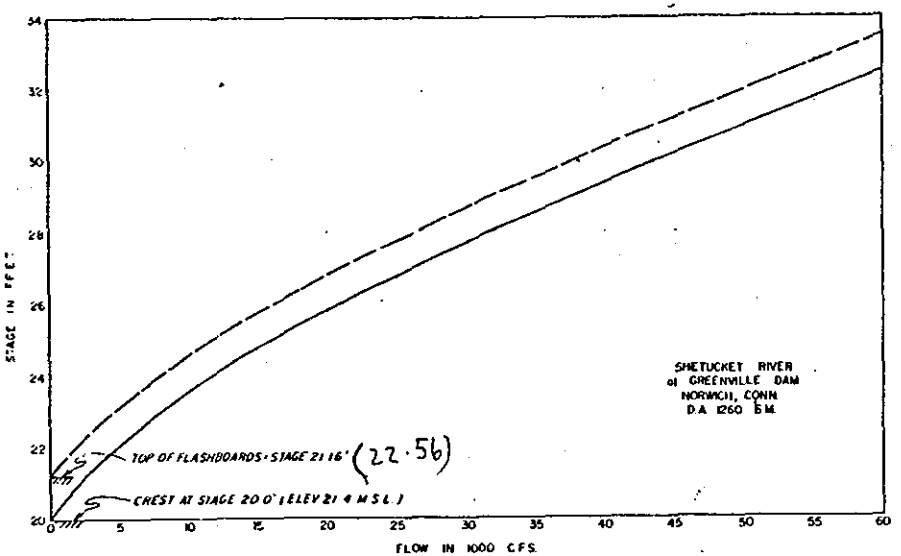
TABLE 7

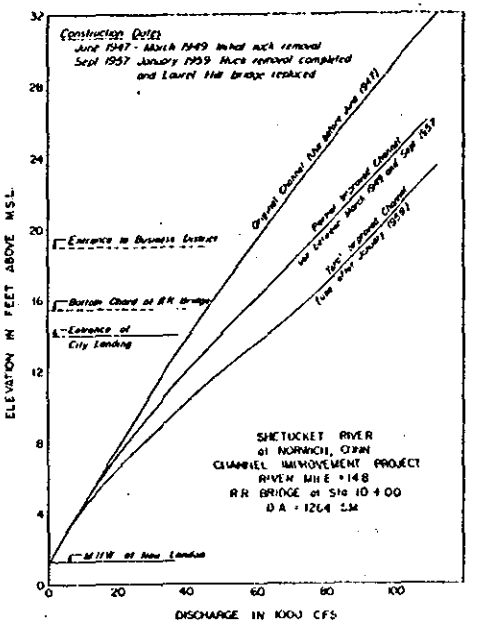
STANDARD PROJECT FLOODS
THAMES RIVER BASIN

Location	River	Drainage Area (sq.mi.)	Peak Discharge (cfs)
South Coventry	Willimantic	121	38,000*
Willimantic	Natchaug	169	28,700*
Willimantic	Shetucket	401	80,300*
Norwich	Shetucket	1,260	129,000*
Webster	French	85	16,300**
Southbridge	Quinebaug	126	28,500**
Putnam	Quinebaug	331	55,000**
Jewett City	Quinebaug	711	61,500**

*Storm centered over Willimantic River basin
** Storm centered over Quinebaug River basin







THAMES RIVER FLOOD CONTROL

RATING CURVES FOR
SHETUCKET RIVER
INDEX STATIONS

JUNE 1967

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE [illegible]

TABLE 8

THAMES RIVER BASIN
CORPS OF ENGINEERS
COMPREHENSIVE FLOOD CONTROL PLAN

Reservoirs	River	State	Drainage Area (sq.mi.)	Flood Control Storage (acre-feet)	Status
Hodges Village	French	Mass.	31	13,250	1959*
Buffumville	Little	Mass.	26.5	11,300	1958*
East Brimfield	Quinebaug	Mass.	67.5	29,900	1960*
Westville	Quinebaug	Mass.	32**	11,000	1962*
West Thompson	Quinebaug	Conn.	74**	25,600	1965*
Mansfield Hollow	Natchaug	Conn.	159	49,200	1952*
Andover	Hop	Conn.	52	16,800	Inactive
South Coventry	Willimantic	Conn.	114	36,900	Inactive
Local Protection Project					
Norwich	Shetucket	Conn.	1260	-	1959*

* Year completed
** Net drainage area

TABLE 9

EFFECT OF FLOOD CONTROL RESERVOIRS AT DAMAGE CENTERS

River	Damage Center	Low Water Stage (ft)	March 1936 Flood				September 1938 Flood			
			Natural		Modified		Natural		Modified	
			Stage (ft)	Flow (cfs)	Stage (ft)	Flow (cfs)	Stage (ft)	Flow (cfs)	Stage (ft)	Flow (cfs)
Quinebaug	Southbridge, Mass. American Optical Company Dam Headwater	0.0	4.8	6,500	2.6	3,400	6.8	13,000	2.6	3,400
Quinebaug	Putnam, Conn. USGS Gage	2.0	17.5	17,000	10.9	6,500	19.5	20,900	10.2	5,600
Quinebaug	Jewett City, Conn. USGS Gage	4.0	24.0	29,200	21.8	22,900	21.7	22,800	15.7	11,900
French	Webster, Mass. USGS Gage	4.5	15.9	4,700	9.7	1,500	12.4	2,800	8.8	1,200
Shetucket	Willimantic, Conn. USGS Gage	2.0	18.4	23,900	13.5	12,900	27.6	52,200	19.1	25,700
Shetucket	Norwich, Conn. Greenville Dam Headwater	20.0	30.6	51,500	29.0	37,200	33.6	75,000	30.6	47,200

River	Damage Center	Low Water Stage (ft)	August 1955 Flood				Standard Project Flood			
			Natural		Modified		Natural		Modified	
			Stage (ft)	Flow (cfs)	Stage (ft)	Flow (cfs)	Stage (ft)	Flow (cfs)	Stage (ft)	Flow (cfs)
Quinebaug	Southbridge, Mass. American Optical Company Dam Headwater	0.0	11.4* 8.4**	36,000* 20,400**	8.1* 3.3**	24,500* 8,000**	10.2	28,500	3.0	9,600
Quinebaug	Putnam, Conn. USGS Gage	2.0	26.5* 25.6**	48,000* 43,800**	16.0* 14.8**	14,100* 12,000**	27.5	55,000	18.6	19,300
Quinebaug	Jewett City, Conn. USGS Gage	4.0	29.0	40,700	19.9	17,500	35.5	61,500	28.6	39,500
French	Webster, Mass. USGS Gage	4.5	26.0	14,000	16.2	4,900	27.5	16,300	19.5	7,600
Shetucket	Willimantic, Conn. USGS Gage	2.0	21.7	33,200	17.4	21,300	35.7	80,300	28.0	53,600
Shetucket	Norwich, Conn. Greenville Dam Headwater	20.0	33.6	65,000	28.6	35,200	40.6	129,000	36.8	94,000

* Includes dam failure on Cady Brook
** Assumes no dam failure on Cady Brook

NOTE: Reservoir system includes: Mansfield Hollow, Buffumville, Hodges Village, East Brimfield, Westville and West Thompson